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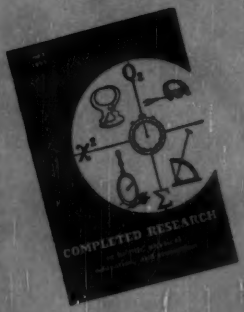

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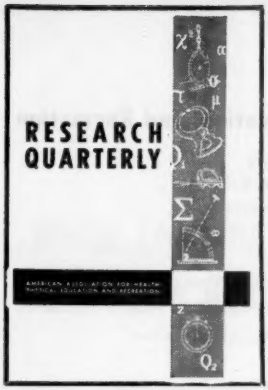

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Motor Learning and Performance as Related to Age and Sex in Two Measures of Balance Coordination[1]

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Abstract

Learning curves of ten groups of male subjects and ten groups of females (16 cases of constant age within each group) were obtained on two large muscle motor coordination tasks. One of these required the maintenance of immobility of a stabilometer; the other involved climbing a free-standing ladder. The theoretical curves fitted to the data were of the exponential type, yielding mathematical coefficients for rate as well as amount of learning in addition to measures of initial skill and plateau level. Variance analyses showed that rate of learning was not influenced by age or sex over the range 6 to 26 years. The amount of learning was unrelated to sex; it was observed to increase during the adolescent period. Performance level (skill) varied considerably with age and was relatively poor in postadolescent females.

ONE OF THE practical problems that the physical educator faces in curriculum planning is the variation in learning capacity of children in relation to their age and, traditionally, in relation to their sex. It is often assumed that the child of primary school age is slow and limited in his ability, as compared with the junior high or high school student. Thus, only the very simple skills are ordinarily taught at the lower ages (6). Of course there are other factors in addition to learning capacity that must be considered in developing suitable curriculums for the different grades, but certainly the planning cannot be sound unless the influence of age on various aspects of learning is understood.

Review of Literature

A review of the literature reveals only a very limited number of publications concerning the effect of age on either rate or amount of learning in the area of large muscle motor skills.[2] A great deal of experimental work has been done concerning age and learning, but almost all of it has dealt with verbal learning or small muscle

[1] From the Research Laboratories of the Department of Physical Education. Appreciation is extended to Franklin M. Henry for advice and encouragement.

[2] Rate of learning (within a learning problem) should not be confused with rate of gain in acquired skill as a function of increasing age. An extensive review of the general area of motor skill and motor learning, including references on the relation of age and sex to skill, has recently been published by Dorothy R. Mohr under the title "The Contributions of Physical Activity to Skill Learning" (*Research Quarterly* 31: 321-50, May 1960).

perceptual-motor learning. For example, the rate of learning a body maze has been found by Hicks and Carr (5) to increase with age; they used children age 8-13 and a college group. Gould and Perrin (2), in comparing children and adults, found that adults had greater ability to learn a stylus maze. However, the learning problem in neither of these studies could be rightly called a true motor task. Both tasks involved the learning of special patterns.

In the general area of learning (as contrasted with the specialized area of true motor learning of the large muscle variety) McGeough and Irion (7) have thoroughly reviewed and summarized the literature concerning the relation between rate of learning and age. They concluded that the rate of learning increases with age during the first two decades of life. Munn (8), on the other hand, interprets the published research on changes in learning as a function of age as showing that the amount of improvement from practice is not related to age in any systematic manner.

In the area of large muscle motor learning in relation to age, most studies have emphasized final performance rather than learning per se. Since learning curves are negatively accelerated, special techniques such as fitted curves and mathematical rate constants are necessary for the measurement of rate of learning. Henry and Nelson (4), using rate constants, have substantiated the conclusion of Munn rather than that of McGeough and Irion; there was no significant difference between boys, ages 10 and 15, in rate of learning three speed of arm movement tasks. However, they suggest that the data show a possible tendency for the rate to become slightly slower rather than faster in the older subjects.

Theoretical Learning Curves

The use of an exponential equation to describe the characteristics of motor learning as a function of the amount of practice has considerable theoretical justification (10). It may reasonably be postulated that learning should taper off with increased practice, approaching a performance plateau, and that the amount of improvement caused by a stated amount of practice (for example, one trial at any point on the curve) should be a constant proportion of the amount still to be learned, this amount being defined as the difference between the skill or performance at that particular trial and the skill at the plateau. In other words, improvement should become relatively more difficult as the plateau is approached. These postulates lead directly to an exponential equation of the type that will be presented later. The parameters of such an equation can profitably be studied with respect to sex and age, as has recently been done in an investigation of fatigue (9).

Problem Investigated

In its broader aspects, the problem has been visualized as an investigation of the influence of age and sex on the amount and rate of motor learning. This includes a determination of whether the exponential theory of the progress of learning is applicable to motor performance. As delimited, it has taken the form of a study of the learning of two large muscle motor skills. It will be noted that the data will also be informative with respect to age and sex differences in standardized motor performance for a wide age range.

One task was learning to balance on a horizontally pivoted platform called a stabilometer. This problem was known to permit large amounts of learning within about 20 minutes in both college students and children. The other task consisted of climbing a short vertical ladder as high as possible before it toppled over. Both tasks and the apparatus used are described in a previous study (1).

Methodology

Subjects and Experimental Design. Three hundred and twenty volunteer subjects, 160 males and 160 females, were tested on both the stabilometer and the ladder climb tests. There were eight boys and eight girls in each of 20 single-year-age groups, which ranged from 6 to 26 years. Within a particular school serving as a source, subjects were obtained from the student body as a whole, rather than from physical education classes, and were unselected insofar as factors which might be expected to influence motor performance were concerned.

It was found that because of the variability of individual learning curves, 16 subjects in each subgroup would be necessary to obtain reasonably smooth empirical learning curves which could be readily fitted by a mathematical equation. Each subgroup, therefore, consisted of 16 subjects of the designated sex with a two-year age range. A physical description of the subgroups is given in Table 1. For some purposes, groups of 40 individuals with a five-year age range have been used as will be explained in context.

The order of testing was mixed, rather than progressive with respect to age, so as to minimize any variation in experimental technique during the long period of testing. The first test alternated between the stabilometer and the ladder climb, so that eventually the two orders of testing were balanced within each age group. The scoring procedures were fully described in a previous study (1).

TABLE 1.—AGE, HEIGHT AND WEIGHT FOR EACH SUBGROUP

Sub-Groups		Males			Females		
(N = 16 in. each)		Age (Yrs.)	Height (In.)	Weight (Lbs.)	Age (Yrs.)	Height (In.)	Weight (Lbs.)
6 and 7 year olds	M	7.10	49.9	60.8	7.00	49.0	54.3
	σ	.61	2.1	7.3	.45	2.6	8.4
8 and 9 year olds	M	9.00	52.9	67.8	9.10	53.2	68.4
	σ	.55	1.7	7.9	.53	1.3	8.8
10 and 11 year olds	M	10.90	58.0	88.8	10.90	57.9	86.3
	σ	.58	2.6	11.5	.55	3.0	13.4
12 and 13 year olds	M	13.10	61.4	98.2	13.00	63.3	114.6
	σ	.65	3.3	17.7	.58	3.2	17.5
14 and 15 year olds	M	15.10	68.3	136.6	15.10	64.3	123.2
	σ	.60	2.0	17.1	.64	2.7	19.4
16 and 17 year olds	M	17.00	70.3	144.0	16.90	63.8	121.8
	σ	.60	2.2	9.8	.64	2.7	23.6
18 and 19 year olds	M	19.00	70.4	166.3	19.00	64.4	118.8
	σ	.55	3.5	19.9	.43	1.5	10.2
20 and 21 year olds	M	20.90	71.7	177.1	21.00	65.4	129.9
	σ	.60	1.1	23.7	.56	3.4	17.2
22 and 23 year olds	M	22.90	70.4	169.1	22.90	65.7	133.7
	σ	.57	2.9	17.1	.51	2.3	19.2
24 and 25 year olds	M	25.00	69.6	163.3	25.00	65.1	135.4
	σ	.67	2.7	22.3	.45	3.0	20.9

Curve Fitting: Subgroup Parameters. For the stabilometer the performance score y_n at any trial after the first is given by the exponential expression $C + a_o e^{-kn}$, where C is the performance at the asymptote or plateau, n is the trial number minus one, a_o is the amount of learning (i.e., the difference between initial score and asymptote), k is the rate constant, which may be defined as $\log_e$ of the ratio of the scores of any two successive trials (in amount above the asymptote), and e is the Naperian log base 2.717. The parameter k is therefore a statistic that gives the rate of learning, i.e., the relative amount of learning (defined as improvement in performance) per trial. Details of the method used to fit exponential curves to the data have been described in other publications (3,9) and need not be repeated here. The curve parameters were determined for each of the age subgroups and for each sex.

For the ladder climb problem, the learning curve goes upward rather than downward to reach the asymptote, so the exponential term takes a negative sign. Preliminary investigation revealed that there was an additional component of learning during the first trial, probably associated with becoming familiar with such factors as the physical handling of the equipment and overcoming apprehensiveness with respect to climbing a free-standing ladder. The complete exponential, therefore, took the form $y_n = C - a_1 e^{-k_1 n} - a_2 e^{-k_2 n}$, with the last component having no observable influence except for the first trial.

Results

Reliability of Scores and Significance of Learning. The reliabilty coefficients have been computed as the intercorrelations between skill in the initial trials 1 and 2, between the final trials 9 and 10, and between the two learning scores (trial 1 minus trial 9 and trial 2 minus trial 10). Since learning progresses rapidly in the early trials, with individual differences in the amount of change, it seems plausible to believe that this method will underestimate the true reliability. The estimated reliability of the individual differences is necessarily lower for learning than for initial or final scores, because a learning score is computed by subtracting the latter from the former, and any random error variances in the two measurements will be additive. The calculated reliability for the initial scores is 0.82 for males and 0.83 for the females on the stabilometer, compared with 0.84 and 0.82 on the ladder climb. For final scores it is 0.85 for the males and 0.89 for females on the stabilometer; on the ladder it is 0.87 for males and 0.91 for females. For the learning scores it is 0.52 for males and 0.59 for females on the stabilometer and 0.65 for males and 0.77 for females on the ladder climb.

Learning scores for both sexes show that a highly significant amount of improvement in performance has taken place during the 10-trial practice period for both tasks. On the stabilometer the t-ratios for the differences between initial and final trials (i.e. the gains in performance used as the learning scores) are $t = 30.4$ for trial 1 minus trial 9, and 24.0 for trial 2

minus trial 10 for all males. They are 30.1 for 1 minus 9, and 27.8 for 2 minus 10 for the females. The corresponding t-ratios for the ladder climb task are 24.1 and 16.8 for males, compared with 25.5 and 19.4 for females ($t = 1.97$ needed for significance at the 5 percent level.)

Learning Curves. To demonstrate the appropriateness of the formulas, the data for each task have been divided into four groups within each sex with a five-year age range in each group. Learning curves have been fitted to these groups. As shown in Figures I and II, the agreement is fairly good between the observed points (raw score means) and the mathematical curves as computed from the parameters for each sex and age group. In the case of the stabilometer, the standard deviations of the discrepancies between the fitted and observed points going from the youngest to the oldest age groups are 1.36, 0.98, 1.26, and 1.29 score units for males, and 0.78, 1.05, 0.72, and 1.57 score units for females. The corresponding standard deviations in the

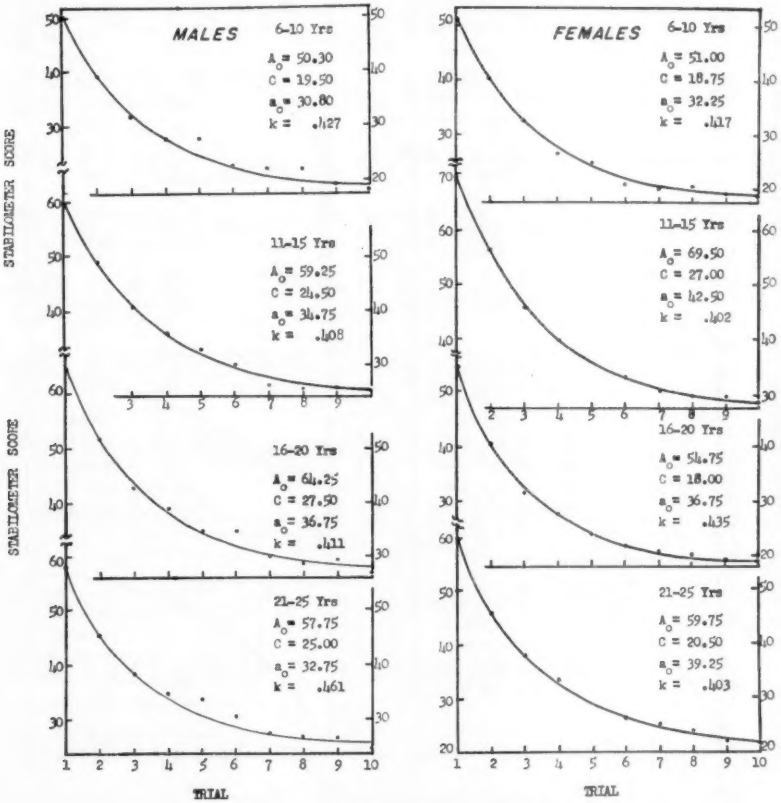

FIGURE I. Stabilometer learning curves.

ladder climb task are 0.40, 0.35, 0.31, and 0.38 for males and 0.46, 0.48, 0.63, and 0.31 for females. Thus in each of eight experiments in each task, the formulas seem to fit the data adequately. On the average, the fitting error is only 3.2 percent of the learning score for the stabilometer and 3.1 percent for the ladder climb.

Relation of Parameters to Performance Scores. The curve parameters are computed by a line of best fit (the mathematical curve) for all of the ten raw data points in a particular subgroup. The scores are the subgroup raw data points for a specified trial; Trial 1 for the initial score, Trial 9 for the final score, and the difference between these two for the learning score. In terms of the parameters, the final performance score is equivalent to C, and the learning score is equivalent to a_o (which is defined as $a_1 + a_2$ in a two component curve). The initial performances score is equivalent to A_o, which

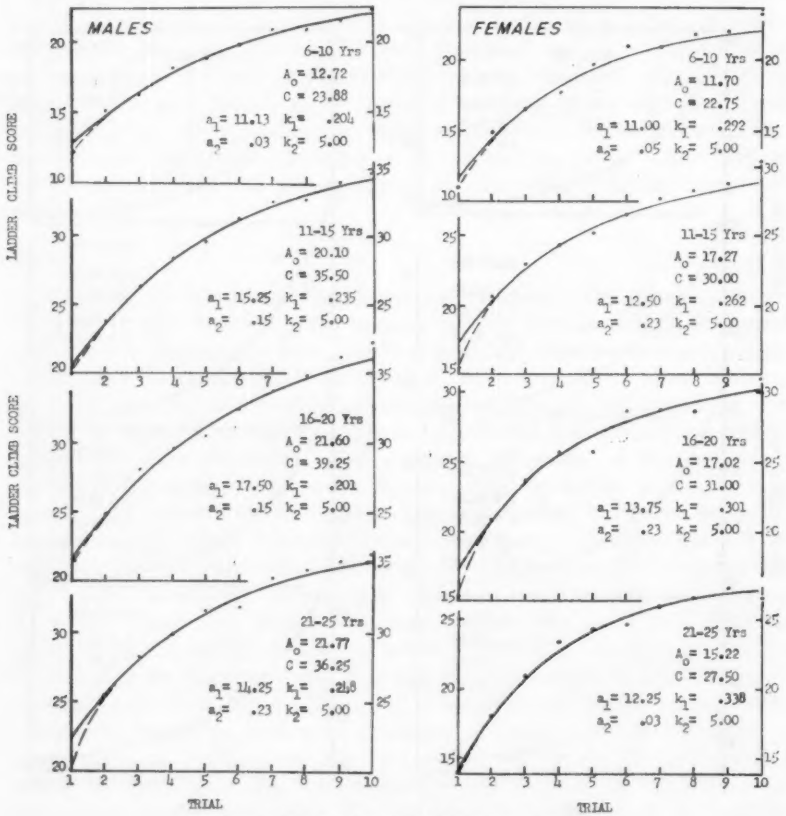

FIGURE II. Ladder climb learning curves.

TABLE 2.—RAW SCORE MEANS, CURVE PARAMETERS, AND FITTING ERRORS

STABILOMETER

N=16	Initial Score				Final Score				Learning Score				Rate Constant		Fitting Error	
	A_o		Trial #1		C		Trial #9		a_o*		Trial #1-#9		k		σ_e	
Age	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
6-7	50.6	52.1	50.6	52.1	19.4	20.0	19.4	21.0	31.3	32.1	31.3	31.1	.453	.421	1.81	0.87
8-9	45.6	45.7	44.3	45.7	15.6	14.4	15.4	14.8	30.0	31.3	28.8	30.9	.394	.410	2.12	1.14
10-11	61.9	63.3	58.3	63.3	25.6	23.8	25.9	25.9	36.3	39.6	32.4	37.4	.310	.404	2.09	1.01
12-13	56.6	71.8	56.6	71.8	21.3	28.1	23.5	30.3	35.3	43.6	33.1	41.4	.402	.317	2.27	1.58
14-15	63.9	68.6	63.9	68.6	28.1	25.0	28.1	29.1	35.8	43.6	35.8	39.5	.432	.423	1.39	1.54
16-17	73.1	66.3	73.1	66.3	30.6	21.3	33.7	20.8	42.4	43.7	39.4	45.6	.366	.423	1.48	0.90
18-19	56.9	46.1	56.9	46.1	26.3	14.4	28.4	15.3	30.7	31.7	28.5	30.8	.406	.428	1.81	0.89
20-21	65.4	51.4	65.4	51.4	26.9	16.9	30.0	18.0	38.5	34.5	35.4	33.4	.436	.438	1.50	0.95
22-23	55.7	57.1	55.7	57.1	21.9	22.5	23.4	21.8	33.8	34.6	32.3	35.3	.419	.423	1.54	1.78
24-25	54.3	65.7	54.3	65.7	24.4	21.9	25.6	23.8	29.9	43.8	28.6	41.6	.417	.396	1.26	1.64
Mean	58.5	58.7	57.9	58.8	24.0	20.8	25.3	22.1	34.4	37.9	32.6	36.7	.404	.408	1.73	1.23
							LADDER CLIMB									
6-7	9.6	7.9	9.6	7.9	20.0	19.4	18.4	18.0	10.5	11.5	8.9	10.1	.219	.274	.571	.540
8-9	13.9	12.0	14.0	12.1	25.3	25.3	23.9	23.9	11.4	13.3	9.9	11.9	.267	.267	.598	.498
10-11	14.2	13.7	14.2	13.8	25.0	26.5	24.4	25.4	10.8	12.8	10.2	11.6	.227	.283	.952	.530
12-13	18.0	14.5	17.9	14.4	34.1	29.4	32.2	27.7	16.1	14.9	14.3	13.3	.270	.241	.607	.585
14-15	20.9	17.4	21.1	17.3	38.8	34.4	37.8	32.0	17.6	17.0	16.6	14.8	.289	.231	.836	.585
16-17	21.4	15.4	21.4	15.4	37.2	30.0	35.4	28.9	15.8	14.6	14.1	13.5	.272	.265	.394	.538
18-19	21.5	14.6	21.4	14.5	39.1	33.8	38.0	32.3	17.7	19.3	16.6	17.8	.224	.283	1.317	.893
20-21	19.0	13.5	18.9	13.6	40.0	28.1	35.7	26.7	21.0	14.6	16.8	13.1	.178	.301	.999	.454
22-23	18.4	14.5	18.4	14.8	35.0	28.1	33.1	27.8	16.6	13.6	14.8	12.9	.220	.325	.392	.641
24-25	19.7	14.0	19.7	13.9	37.8	29.1	35.9	28.4	18.2	15.1	16.2	14.5	.236	.330	.937	.566
Mean	17.7	13.8	17.7	13.8	33.2	28.4	31.5	27.1	15.6	14.7	13.8	13.3	.240	.280	.760	.593

*a_o is composed of a_1 plus a_2.

is defined as C + a_0 for the stabilometer and C — a_0 for the ladder task. The raw scores offer no equivalent for the parameter k.

Mathematical curves have been fitted to each of 40 subgroups. The raw scores and parameter values are given in Table 2. The average fitting error for these subgroups is 4 percent of the learning score for the stabilometer and 5 percent for the ladder. Considering each subgroup as a synthetic individual, the correlation between raw score and parameter is r = .99 for A_0, .98 for C and .95 for a_0 in the case of males on the stabilometer, and .99, .97, and .95 for females. It is .97, .99, and .97 for males on the ladder task, and .99, .98, and .98 for females. It was impractical to fit 640 individual mathematical curves to the raw data, but in view of the large correlations for the subgroup curves it is reasonable to assume that statistical analyses based on raw scores would permit valid inferences concerning the parameters.

Variance Analyses. The raw scores of the 320 individuals were subjected to variance analysis as shown in Table 3. The F ratios are statistically significant for all of the main effects, except that there is no significant sex difference in initial scores for the total group on the stabilometer or learning scores on the ladder task. When the sexes are considered separately (age w/i sex), it is seen that both males and females have a significant age effect in initial and final scores on the stabilometer, although only the females show a significant age effect in the learning score. On the ladder task, both males

TABLE 3.—VARIANCE ANALYSES OF PERFORMANCE AND LEARNING SCORES

Source of Variance	df	Initial Score		Final Score		Learning	
		MS	F	MS	F	MS	F
STABILOMETER							
Total Score	319	318.743	.....	125.718	.....	198.285	.....
Sex	1	64.000	0.24	864.230	8.32[a]	1399.000	7.48[a]
Age	9	1814.111	6.88[a]	511.000	4.92[a]	488.330	2.61[a]
(age w/i sex)	(9)	(1028.333)	(4.12)[a]	(443.440)	(4.54)[a]	(179.400)	(1.05)
(age w/i sex)	(9)	(1467.333)	(5.23)[a]	(453.560)	(4.12)[a]	(397.800)	(1.96)[a]
Interaction:							
Age × Sex	9	681.560	2.58[a]	386.000	3.72[a]	153.000	0.82
Error	300	263.837	.....	103.890	.....	186.942	.....
LADDER CLIMB							
Total Score	319	35.389	.....	105.661	.....	47.325	.....
Sex	1	1217.000	52.02[a]	1527.000	19.86[a]	21.528	0.48
Age	9	303.568	12.98[a]	920.889	11.98[a]	161.743	3.628[a]
(age w/i sex)	(9)	(243.656)	(8.45)[a]	(740.889)	(9.12)[a]	(118.025)	(2.53)[a]
(age w/i sex)	(9)	(95.556)	(5.32)[a]	(271.778)	(3.75)[a]	(70.000)	(1.64)
Interaction:							
Age × Sex	9	35.667	1.52	91.778	1.19	28.778	0.65
Error	300	23.397	.....	76.883	.....	44.578	.....

[a] Significant at the 5 percent level. This requires F = 3.88 for sex difference, 1.91 for both age and interaction, and 1.94 for age w/i sex.
[b] The two age w/i sex F's are for males and females respectively. Both are significant.

and females show a significant age effect in initial and final scores. However, only the males show a significant age effect in the learning score. The presence of significant age $\times$ sex interactions for initial and final stabilometer scores (Table 3) means that the regression of these variables on age is probably different in the two sexes.

Regression on Age. The proportion of individual difference variation accounted for by regression on age is actually not very great. For the stabilometer, the nonlinear correlation coefficients (η^2) between raw score and age for males are 0.20 for initial scores, 0.21 for final scores, and 0.06 for learning, while the corresponding values for females are 0.24, 0.20 and 0.10. For the ladder climb the corresponding figures are 0.27, 0.35, and 0.13 for males, compared with 0.24, 0.18, and 0.09 for females. Nevertheless, there is a statistically significant age regression for both sexes and both tasks in initial and final scores, and probably for ladder learning in the males. The test for significance is the F ratio for "between subgroups" variance in Tables 4 and 5. These tables show that the regression is nonlinear, except for the case of ladder learning in the males. For this reason, a graphic presentation of the relationship seems necessary and has been given in Figure III.

Age and Sex Differences—Stabilometer. The initial performance becomes poorer (i.e., the scores are larger) as the age of the subjects varies from age 7 to age 17 (Figure III). Using the error term of the variance analysis (Table 3) to compute t ratios, it can be shown that the change over this age range is conventionally significant for both the males ($t = 3.94$) and the females ($t = 2.47$). The worst performance of the females occurs earlier, however, at age 12 ($t = 3.43$). The decline in performance is followed by an improvement that occurs between ages 17 and 19 in both sexes. It is significant, since the t ratio is 2.82 for males and 3.51 for females. There is no significant change after age 19 in the males ($t = 0.45$); the females, however, become significantly poorer by age 23 and older. It should be noted that some statisticians question whether the t ratios computed from the variance analysis yield exact probabilities, but this should be of no concern in the present case. These t ratios are in general either quite high or quite low, whereas the possible error would only be of concern in borderline cases. The critical t for 5 percent significance is 2.04.

A somewhat similar age pattern is seen for the final performance scores. The males progressively become worse as the age increases from 7 to 17 ($t = 3.97$) but do not change significantly thereafter. The females become significantly poorer between age 7 and age 13 ($t = 2.58$), but they improve significantly between age 13 and 19 ($t = 4.17$). At older ages their performance is again poorer ($t = 2.36$ by age 25).

Both sexes reach their peak in the amount of learning at age 17. The increase from the lower age to age 17 is significant ($t = 2.19$ for males and 3.00 for females). This is followed by a decrease between ages 17 and 19

TABLE 4.—ANALYSIS OF REGRESSION VARIANCE (STABILOMETER)

Source of Variance	df	Initial Score		Final Score		Learning[b]	
		MS	F	MS	F	MS	F
MALES							
Total	159	293.661	.....	117.311	.....	161.304	.....
Linear Regression	1	1201.439	4.17[a]	1044.161	9.37[a]	5.258	0.03
Deviation from Linear	8	886.743	3.46[a]	365.844	3.74[a]	212.263	1.33
Between Subgroups	9	921.703	3.60[a]	441.212	4.51[a]	189.249	1.19
Within subgroups	150	255.979	.....	97.877	.....	159.627	.....
Error of Linear Estimate	158	287.916	.....	111.444	.....	162.292	.....
FEMALES							
Total	159	345.457	.....	129.456	.....	203.387	.....
Linear Regression	1	192.247	0.56	13.071	0.10	306.246	1.51
Deviation from Linear	8	1025.088	3.30[a]	504.201	4.57[a]	422.179	2.21[a]
Between Subgroups	9	932.550	3.01[a]	449.643	4.08[a]	409.298	2.14[a]
Within subgroups	150	310.232	.....	110.247	.....	191.032	.....
Error of Linear Estimate	158	346.427	.....	130.194	.....	202.736	.....

[a] Significant at the 5 percent level. This requires F = 3.91 for linear regression, 2.00 for deviation of subgroups from linear and 1.94 for between subgroups.

[b] When the learning scores of the two sexes are pooled (N = 320), the F-ratio is 1.07 (non-significant) for linear regression, 3.79 (significant) for deviation from linear, and 3.49 (significant) for between subgroups.

TABLE 5.—ANALYSIS OF REGRESSION VARIANCE (LADDER CLIMB)

Source of Variance	df	Initial Score		Final Score		Learning[b]	
		MS	F	MS	F	MS	F
MALES							
Total	159	49.974	.....	118.565	.....	50.633	.....
Linear Regression	1	1186.751	35.19[a]	4157.208	44.70[a]	934.528	20.75[a]
Deviation from Linear	8	124.475	4.31[a]	314.048	3.87[a]	50.789	1.14
Between Subgroups	9	242.506	8.40[a]	741.066	9.13[a]	148.983	3.33[a]
Within subgroups	150	28.882	.....	81.215	.....	44.732	.....
Error of Linear Estimate	158	33.722	.....	93.004	.....	45.039	.....
FEMALES							
Total	159	22.338	.....	83.833	.....	44.151	.....
Linear Regression	1	260.452	12.50[a]	922.664	11.75[a]	219.475	5.10[a]
Deviation from Linear	8	76.226	4.26[a]	190.594	2.63[a]	53.781	1.27
Between Subgroups	9	96.699	5.41[a]	271.935	3.75[a]	72.191	1.67
Within subgroups	150	17.877	.....	72.547	.....	42.475	.....
Error of Linear Estimate	158	20.831	.....	78.524	.....	43.047	.....

[a] Significant at the 5 percent level. This requires F = 3.91 for linear regression, 2.00 for deviation of subgroups from linear and 1.94 for between subgroups.

[b] When the learning scores for the two sexes are pooled (N = 320) the F-ratio is 23.30 for linear regression, 4.73 for deviation from linear, and 5.36 for between subgroups (all of these are significant).

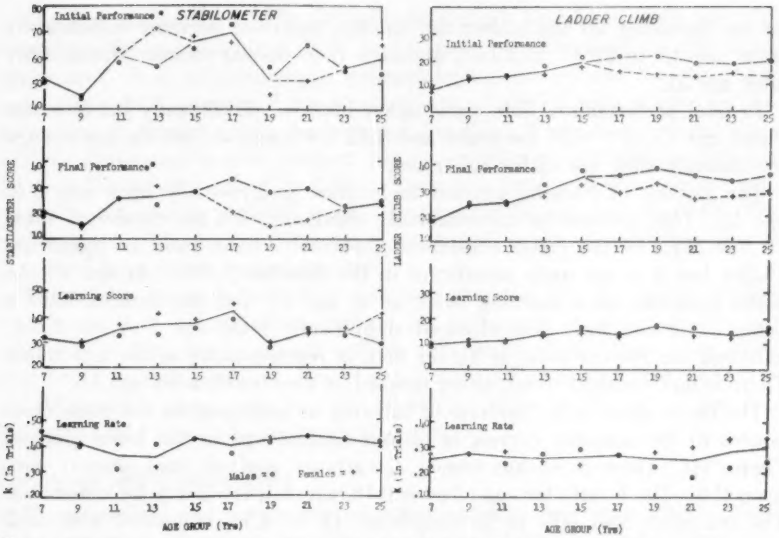

FIGURE III. Regression on age. (Note that high initial or final scores on the stabilometer represent poor performance, whereas high scores represent good performance on the other variables).

($t = 2.26$ for males and 3.06 for females). There is no significant age effect thereafter.

The curve constant k, which describes the rate of learning, is plotted against age in the lower part of Figure III. It can be seen by inspection that there is no age trend. This is confirmed by a variance analysis (not shown). The F ratio for the age effect is only 1.39, which is definitely too low to be significant. The sex effect is also nonsignificant ($F = 0.09$).

The variability of scores within the age-sex subgroups does not vary significantly with age or with sex for any of the measures. This has been determined by a variance analysis (not shown). The F ratios for the age effect for initial, final learning scores are 1.43, 1.19 and 1.53; for the sex effect they are 0.27, 0.11 and 1.54.

The female subjects considered as a total group irrespective of age start the stabilometer test with an initial score that does not differ from the males' performance. They learn 12.6 percent more and end the test with a score that is 12.7 percent better than the male performance. These sex differences were shown to be statistically significant (Table 3).

Age and Sex Differences—Ladder Climb. The initial performance improves as the subjects progress in age from 7 to 15 years (see Figure III). Using the error term of the variance analysis (Table 3) to compute t ratios, it can be shown that the change over this age range is conventionally significant for both the males ($t = 6.73$) and the females ($t = 5.50$). No significant change

occurs thereafter for the males; the females, however, decrease significantly from age 15 to 21 ($t = 2.16$), although they do not change significantly after age 21.

In final performance, both sexes again improve significantly between age 7 and age 15 ($t = 6.26$ for males and 4.52 for females), but do not change significantly after age 15 for either sex.

The amount of learning appears to increase progressively from age 7 to age 15. This increase is conventionally significant for the combined sexes ($t = 3.71$). In the males considered separately, the t ratio is significant (3.26) but it is not quite significant in the females (1.99). At age 19 the males have the same learning score as at age 15, but the females have a better score and have now changed significantly from age 7 ($t = 3.26$), although the 19-year point is higher than is representative of the age trend. There is no consistent trend, either upward or downward, after age 15.

The curve constant k_1, the rate of learning as measured by the main component of the learning curves, is plotted against age in the lower part of Figure III. There is no age trend. A variance analysis (not shown) confirms this. The F ratio for age effect is 0.18, which is too low to be significant. The sex effect also fails to be significant ($F = 4.32$, compared with 5.12 required at the 5 percent level).

Variance analyses (not shown) of the variability of scores within the age-sex subgroups show no significant age or sex effects for initial, final, and learning scores. The F ratios are 1.95 for initial scores, 2.31 for final scores, and 2.09 for learning scores, compared with 3.18 required for 5 percent significance. For the sex effect, the F ratios are 0.211, 0.429, and 0.186, which are clearly nonsignificant (5.12 required for significance).

When the sex difference is examined for the total group, neglecting any age effects, the results are quite different in the ladder climb as compared with the stabilometer. The initial ladder performance is 22 percent poorer for females compared with males, and the final performance is 14 percent poorer, both differences being statistically significant (see sex effect, Table 3). There is no significant sex difference in learning scores.

Discussion

If practice were continued over an extended period of many days or weeks, new factors in the learning situation might very well cause further improvement beyond the asymptote of the present mathematical curves. Some learning situations or problems might require several exponential terms to account for learning in stages, or to account for different rates of improvement for different factors involved in performance. There are types of learning, insight for example, that would not occur in an exponential manner. The influence of variations in motivation may in some cases not be subject to simple mathematical representation. Nevertheless, the major trend of motor learning of the type involved in the two present examples seems to follow the curve of an exponential equation reasonably well.

The fast component $a_2e^{-k_2n}$ of the ladder climb learning (which was discussed in the methodology) is a rapid phase superimposed on the main component. It is substantially completed by the end of the first trial and makes up only 7 percent of the total amount of the learning score (a_o) for males and 9 percent of the learning for females. A variance analysis (not tabled) shows that this component has no significant relationship with age ($F = 0.26$) or with sex ($F = 0.06$). Since it is small and unimportant with respect to the present problem, it has been ignored for the main analysis. The major trend of the ladder climb learning as well as stabilometer learning is described by a single exponential term.

The results clearly indicate that with respect to the rate of learning parameter k, there is no age effect and no sex difference in either of the two motor skills. This result was not entirely unexpected; there is one other study that bears on this question. Henry and Nelson (6) reported that there was no difference between boys age 10 and age 15 years in the rate of learning parameter in a speed of arm movement test.

Summary and Conclusions

Three hundred and twenty subjects were tested on two large muscle motor tasks in order to determine the influence of age and sex on motor performance and on the amount and rate of learning. A secondary problem was to determine if the short-term phase of motor learning could be described by a simple mathematical curve of the exponential type.

All subjects performed two learning tasks. The first consisted of maintaining the body upright while standing on a pivoted board (stabilometer), with the object of preventing any movement of the board. The other task required the subject to maintain balance while attempting to climb an unsupported vertical ladder. Success in both tasks required learning to coordinate large muscle movements. Approximately 50 percent improvement in performance occurred during the learning period.

The data for each task and sex were divided into 20 subgroups, each consisting of 16 individuals of a single sex and an inclusive age range of two years. The total age range was 6 to 26 years for each sex. The equation $y = C + a_oe^{-kn}$ was fitted to each subgroup, the average fitting error being 4 percent of the total amount of learning for the stabilometer and 5 percent for the ladder climb. Curve parameters C and a_o were found to be highly correlated with their raw score equivalents, "final skill" and "learning." The parameter k of the mathematical curve, used as a measure of relative rate of learning, averaged .406 for the stabilometer and was significantly slower, .260, for the ladder climb task. A variance analysis showed that the k's were not significantly influenced by age or sex in either task.

The amount of improvement caused by practice did not change appreciably between ages 6 and 12 in either task. Variance analysis showed that in both tasks and for both sexes there was a significant upward trend in the amount learned between approximately ages 12 and 17, followed by a decline by

age 19 with no systematic change thereafter. These trends were much more pronounced in the stabilometer task. There was no significant sex difference in amount of learning in the ladder climb and probably none in the stabilometer.

Initial and final performance scores in the ladder climb task increased with age and were the same for boys and girls in the prepubescent years. The boys continued to improve through pubescence until age 19 while the girls exhibited a slight postpubescent decline. In contrast, performance on the stabilometer task became progressively poorer in both sexes with increased age through adolescence. The adverse effect of adolescence, and recovery from it, seemed to occur several years earlier in females. From age 16 to 21 the females performed much better than the males, but this sex difference disappeared after age 22.

These results lead to the following conclusions, which are of course somewhat restricted, since only two tasks were studied and the learning was only observed through its short-term phase.

1. Motor learning progresses in accordance with an exponential law of diminishing effectiveness of practice.
2. The rate of learning in large muscle skills is independent of age and sex over the range 6 to 26 years.
3. The amount of motor learning ability, defined as improvement between the initial and final levels of skill, increases through the adolescent period. For stabilometer learning, the postadolescent ability declines to a relatively constant figure that is approximately the same as in the preadolescent period.
4. There are no sex differences in motor learning ability in the age range 6 to 26 years.
5. There is no appreciable sex difference in the initial performance of these novel and unpracticed motor tasks until after pubescence. The postpubescent difference appears several years earlier in females.
6. Initial performance ability passes through a depression during the adolescent period in stabilometer balancing, whereas in ladder balancing, it is at its best during this period.

References

1. Bachman, John C. "Specificity vs. Generality in Learning and Performing Two Large Muscle Motor Tasks." *Research Quarterly* 32: 3-11; 1961.
2. Gould, M. C., and Perrin, F. A. C. "A Comparison of the Factors Involved in the Maze Learning of Human Adults and Children." *Journal of Experimental Psychology* 1: 122-54; 1916.
3. Henry, Franklin M. "Prediction of World Records in Running Sixty Yards to Twenty-Six Miles." *Research Quarterly* 26: 147-58; 1955.
4. Henry, Franklin M., and Nelson, Gaylord A. "Age Differences and Interrelationships between Skill and Learning in Gross Motor Performance of Ten- and Fifteen-Year Old Boys." *Research Quarterly* 27: 162-75; 1956.
5. Hicks, V. C., and Carr, H. A. "Human Reactions in a Maze." *Journal of Animal Behavior* 2: 98-125; 1912.

6. LAPORT, WILLIAM R. *The Physical Education Curriculum.* Los Angeles: University of Southern California Press, 1937.
7. MCGEOUGH, J. A., and IRION, A. L. *The Psychology of Human Learning.* New York: Longmans, Green and Company, 1952.
8. MUNN, NORMAN L. "Learning in Children," in *Manual of Child Psychology.* L. Carmichael, editor. New York: John Wiley and Sons, 1954.
9. RICH, GEORGE Q. "Muscular Fatigue Curves of Boys and Girls Age Eight to Seventeen." *Research Quarterly* 31: 485-98; 1960.
10. WOODROW, H. "Interrelations of Measures of Learning." *Journal of Psychology* 10: 49-73; 1940.
11. WOODWORTH, ROBERT S., and SCHLOSSBERG, H. *Experimental Psychology.* New York: Henry Holt and Company, 1954.

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Comparison of Three Programs of Progressive Resistance Exercise

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Abstract

Eighty male subjects of college age were subjected to the quadriceps (left) lift in isotonic fashion. The 80 were separated into three groups. Each group used a specific variation of progressive resistance exercise for an eight-week period. Initial and final measurements were taken on muscular circumference and strength. Data were statistically treated by analysis of variance. All three methods showed significant strength gains that were not significantly different from each other. Only the DeLorme-Watkins technique had significant circumferential gain. The traditional bulk and traditional strength methods had no significant circumferential gain.

PROGRESSIVE RESISTANCE EXERCISE today is one of the most useful and frequently prescribed therapeutic procedures used in physical medicine (4). Since DeLorme's original report (2) on the effect of production of muscular strength and hypertrophy by progressive resistance exercise, many hospitals and physical medicine clinics have adopted its use for restoration of normal muscle bulk and strength. Physical educators and athletic coaches are rapidly adopting these principles in order to improve athletic performance. The application of heavy resistance exercise has many uses in the treatment of various disabling conditions as well as for improving the effectiveness of the normal working muscle.

Progressive resistance exercise has been subject to experimental research to determine its value as compared to other activities for the development of muscular strength, endurance, and hypertrophy. In research thus far conducted, progressive resistance exercise has shown satisfactory results with a very low incidence of ill effects.

The problem which confronts those concerned with physical performance today is the selection of the best method of progressive resistance exercise for the development of skeletal muscle. It is of prime importance to those with physical injury to be able to return to normal activity as soon as possible, but in a normal capacity, with the least amount of time lost and at a minimum expense.

Purpose

Macqueen (5) claimed without listing research evidence that the traditional maximum method has proved to bring quicker and greater gains in strength and hypertrophy. He also advocates that this method might be used with advantage in the medical application of PRE in preference to the

fractional system. The purpose of this study was to compare a scientific method of PRE with a traditional method regarding the production of muscular strength and hypertrophy.

Procedure

This study was conducted during the fall, winter, and spring quarters of the school year 1955-56. Progressive resistance exercises were applied over an eight-week period to the left quadriceps muscles of each of 80 male subjects, varying in age from 17 to 25 years. Their weight range was from 130 to 219 pounds. The subjects were all normal, healthy students registered in general activity courses at the Brigham Young University.

The division of subjects into groups was accomplished by normal registration procedures. From ten sections of the weight training classes offered, six sections were selected for the research study. These sections were those taught by staff members interested in the project. Students were informed of the project at the first meeting and were asked to give full cooperation or to change to a non-research section. Only a few declined. Two sections were assigned to each of the three methods by drawing numbers from a hat. Early in the project one instructor was unable to carry on the program; therefore, two classes were dropped from the research project. Of the four remaining sections, two remained with the DeLorme-Watkins method, one with the traditional bulk or hypertrophy program and one with the traditional strength program. The DeLorme-Watkins group was considered the criterion or control group.

All subjects were given two weeks of general conditioning exercises prior to the time the initial tests were given. The reconditioning exercises were given in an attempt to stabilize the general condition of all subjects. These exercises were as follows (1): (a) a run of two laps of indoor track, approximately 220 yards; (b) push-ups from close position beginning with five and increasing one each day of exercise; (c) pull-ups from bar performed as in (b); (d) abdominal exercises, straight and rotating, increasing in number and severity each day of exercise; (e) abduction exercises of the lower extremities; (f) adduction exercises of both lower extremities; (g) shoulder adduction exercises; (h) back extension exercises; (i) extension exercises of the thighs and legs; (j) lateral flexion exercises of the trunk; (k) plantar and dorsal flexion exercises of the feet; (l) deep knee bends, one extremity at a time; and (m) stretching exercises of hamstrings and heel cords.

The programs of PRE used to compare the two were as follows.

1. The method of exercise described by DeLorme and refined by DeLorme and Watkins (3). Forty-seven subjects were used in this method.

2. (a) The traditional hypertrophy or bulk program described by Macqueen in his 1954 article in *The British Medical Journal.* (5). Eighteen subjects were used in this method. (b) The traditional power program described by Macqueen (5). Fifteen subjects were used in this method.

DELORME AND WATKINS TECHNIQUE

In the DeLorme technique the subject was seated on a table with the knees flexed to an angle of 90° and a boot was strapped to the foot. The subject could stabilize himself by placing his hand on the table posterior to the hip level. The subject was now in a starting position. The leg was extended completely through the range of motion of the particular subject. The leg was extended and lowered at the same rate. The movements were executed slowly, rhythmically and without haste, but not so slowly that just holding the weights would cause fatigue. Sudden, jerky, or pendular movements were avoided while exercising. A momentary pause at the end of each repetition was advocated.

The importance of lifting the weight completely through the range of motion in extension cannot be overemphasized. The vatus medialis muscle functions mainly during the last 15° of extension.

Program of Exercise. In this program (1) of progressive resistance exercise the subject exerted his maximum power once each week. The maximum quadriceps power for clinical purpose was taken to be the maximum poundage that could be lifted to the point of complete extension of the leg for one repetition. It was recorded as the 1 RM and was shown in pounds. The ten repetitions maximum was determined at the beginning of the exercise program and once each week thereafter and was recorded as the work load index.

At the beginning of the exercise program the 10 RM was determined in the following manner. The subject selected a weight which was assumed to be lighter than his 10 RM. He then attempted to lift the weight through the range of motion ten times. If the weight could be lifted more than ten repetitions, weight was added and the procedure was repeated until a weight which could be lifted only ten times was determined. This weight was then used as the index of work for each work period. The 1 RM was determined in the same manner as the 10 RM except that weight was added until that weight which could be extended one repetition was reached.

Frequency and Length of Exercise Periods. The subjects exercised three days a week or every other day. Monday, Wednesday, and Friday were used in this program of exercise. Friday was selected for the day of testing. Each Friday a new 10 RM and 1 RM were determined. The new 10 RM was used as the work load index for the following week. No weight heavier than this was used during the exercise periods until a new 10 RM was determined on test day. The 1 RM was recorded as an index of increase in strength.

Each work period was of approximately 15 minutes duration and was performed in the following manner:

1. First set of ten repetitions, use ½ of 10 RM.
2. Second set of ten repetitions, use ¾ of 10 RM.
3. Third set of ten repetitions, use 10 RM.

Exercise was performed at the same hour each exercise day. Approximately one-half to one minute rest period was allowed between bouts of exercise.

TRADITIONAL HYPERTROPHY OR BULK PROGRAM

This program differs from the DeLorme and Watkins technique only in that fractional (½ and ¾ of 10 RM) sets of ten repetitions were eliminated and the maximum resistance was used in their place. Hence, in this program each work period consisted of the following:

1. First set of ten repetitions, use the 10 RM.
2. Second set of ten repetitions, use the 10 RM.
3. Third set of ten repetitions, use the 10 RM.

TRADITIONAL POWER (STRENGTH) PROGRAM

This program differs from the DeLorme and Watkins technique essentially in that it is one of decreasing numbers of repetitions performed with increasing resistance. Thus, each work period is performed in the following manner:

1. First set of ten repetitions, use 10 RM.
2. Second set of repetitions increase 5-10 pounds, complete as many repetitions as possible.
3. Subsequent sets of repetitions, continue to increase the weight 5-10 pounds each set, doing as many repetitions as possible until the 1 RM is reached, after which additional weight is added and the subject attempts one more lift.

ADMINISTRATION PROCEDURE

Data Recorded. Circumferential measurement of the left thigh at points four and eight inches above the superior border of the patella were carried out with a 0.25 cm. steel tape. Tension was applied through the use of a gulick spring attached to the end of the tape. The gulick spring was used to insure the application of the same amount of tension during all measurements. All measurements were done by the same observer within each group. The thigh was measured at constant levels as described above. Silver nitrate was used to mark the levels to make sure that every measurement was taken at the same point. All circumferential measurements were taken in a supine position with the quadriceps muscles relaxed.

Strength Measurements. Isotonic strength measurements were recorded as the 1 RM. When the 1 RM was determined, the metal plates, bar, collars, and boots were weighed with a set of spring scales. The same scales were used for each measurement. This weight was recorded as the isotonic strength.

Supervision. The exercise programs were administered under close supervision at all times. A qualified physical therapist or a competently trained, professional physical educator was in the room at all times. Special care was taken to insure that subjects followed proper techniques. The importance of maximal effort was stressed constantly. Motivation of interest and encouragement toward improvement was attempted at all times.

During test days the 10 RM and the 1 RM were carefully checked by the observer in an effort to eliminate compensatory movements which might falsify the results of the testing.

Results

TRAINING BY THE DELORME METHOD

Circumferential Measurements at the 4-inch Level. The individual circumferential measurements of all subjects training by the DeLorme procedure with one exception showed an increase at the 4-inch level. The range of individual circumferential measurements was 0 to +5 cm.

The mean measurement of the 47 subjects at the 4-inch level at the beginning of the training program was 44.013 ± .452 cm. The mean measurement at the termination of the training program was 45.936 ± .51 cm. The mean gain of this group was 1.923 ± .160 cm. When comparing the initial mean with the final mean, the results recorded by the above subjects were significant beyond the 1 percent level of confidence with a P value of .0092. During the first two weeks of exercise, there was a marked increase in muscle circumference with very little increase during the second two weeks. Between the fourth and sixth weeks, there was a sharp decrease. From the sixth to the seventh week there was a dramatic increase, with a leveling off from the seventh to the eighth week.

Circumferential Measurement at the 8-inch Level. There was a slight decrease from the second to the third week and a slight increase again between the third and fourth weeks. There was a sharp decrease between the fourth and sixth weeks and a strikingly sharp increase between the sixth and seventh weeks, and a steady increase between the seventh and eighth weeks.

The mean gain of this group was 1.620 ± .14 cm. The initial mean measurement, when compared with the final mean measurement of the 47 subjects at the 8-inch level, showed an increase in circumference which is significant beyond the 5 percent level of confidence with a P value of .0425.

Strength Measurements (10 RM). The results of tests between the initial and final measurements of the work load index (10 RM) showed an increase ranging from 14 to 64 pounds, with a mean gain of 29.895 ± 1.636. This increase is considered statistically significant well beyond the 1 percent level of confidence.

Strength Measurements (1 RM). The measurement was recorded as the isotonic strength measurement. There was an increase from the initial to final measurement of all subjects, ranging from 5 to 64 pounds. The mean initial measurement of the 47 subjects was 56.5 ± 1.6 pounds. The mean final measurement of these subjects was 87.77 ± 2.0. There was a mean increase of 31.28 ± 1.64 pounds. With a t value of 12.214, allowing 46 degrees of freedom, the results may be considered significant (P .001). This increase is statistically significant well beyond the 1 percent level of confidence.

TRAINING BY THE TRADITIONAL HYPERTROPHY OF BULK PROGRAM

Circumferential Measurements at the 4-inch Level. The mean measurement of the 18 subjects at the 4-inch level at the beginning of this program was

TABLE 1.—A COMPARATIVE SUMMARY FROM THE RESULTS OF THREE PROGRAMS OF PROGRESSIVE RESISTANCE EXERCISE

		DeLorme and Watkins	Traditional, Hypertrophy or Bulk	Traditional Power (Strength) Program
Number of Cases		47	18	15
Difference of the mean between the initial and final measures of girth at the 4-inch level in cm.		1.923	.29	.7467
t Ratio		2.83	.31	.6296
P Value		.0092	.8	.6[a]
Difference of the mean at the 8-inch level in cm.		1.62	.16	—.1867
t Ratio		2.12	.167	.165
P Value		.0425	.90[a]	.90[a]
Difference of the mean of strength between initial and final measures in lbs.	10 RM	29.895	41.42	38.47
	1 RM	31.28	36.28	33.82
t Ratio	10 RM	30.045	10.36	13.22
	1 RM	12.214	7.99	9.19
P Value	10 RM	.001[b]	.001[b]	.001[b]
	1 RM	.001[b]	.001[b]	.001[b]

[a] No significance
[b] Beyond 1 percent level

44.57 cm. The mean measurement at the end of the training program was 44.86 cm. Hence, the mean gain was 0.29 cm. This gain was not statistically significant. The range of individual difference between initial and final measurements was —1.2 to +1.3 cm.

Circumferential Measurements at the 8-inch Level. The range of individual differences between initial and final measurement was —0.8 to +3.3 cm. The initial mean measurement was 52.26 cm. and the final mean measurement was 52.42 cm. for a gain of 0.16 cm. This gain was not statistically significant.

Strength Measurements (10 RM). The range of strength gain from initial to final measurement was 21-57 pounds. The initial mean measurement was 46.36 pounds and the final mean measurement was 87.78 pounds for a mean gain of 41.42 pounds. This gain is statistically significant well beyond the 1 percent level of confidence.

Strength Measurements (1 RM). The range of strength gain from initial to final measurement was 24.5 to 52.5 pounds. The initial mean measurement was 62.78 pounds and the final mean measurement was 99.06 pounds for a mean gain of 36.28 pounds. This gain is also statistically significant well beyond the 1 percent level of confidence.

TRAINING BY THE TRADITIONAL POWER (STRENGTH) PROGRAM

Circumferential Measurement at the 4-inch Level. The range of individual differences between the initial and final measurements for the 15 subjects was —2.0 to +6.1 cm. The initial mean measurement was 43.1866 cm. and the final mean measurement was 43.9333 cm. for a mean gain of 0.7467 cm. This gain is not statistically significant.

Circumferential Measurements at the 8-inch Level. The range of individual differences between the initial and final measurements was —2.6 to +1.9 cm. The initial mean measurement was 51.6533 cm. and the final mean measurement was 51.4666 cm. for a mean loss of —0.1867 cm. This difference is not statistically significant.

Strength Measurements (10 RM). The range of strength gain from initial to final measurement was 25 to 52 pounds. The initial mean was 40.93 pounds and the final mean measurement was 79.40 pounds for a mean gain of 38.47 pounds. This gain was statistically significant well beyond the 1 percent level of confidence.

Strength Measurements (1 RM). The range of strength gain from initial to final measurement was 13 to 58 pounds. The initial mean measurement was 64.35 pounds and the final mean measurement was 98.17 pounds for a mean gain of 33.82 pounds. This gain was also statistically significant well beyond the 1 percent level.

Summary

The preceding results as shown in the data were treated statistically by analysis of variance in order to show the significance or lack of significance of mean gains between the three exercise programs. Tables 2 and 3 give these results in brief form.

Circumferential Measurements at the 4-inch and 8-inch Level. The DeLorme-Watkins program was the only one of the three programs used which produced a statistically significant circumferential increase. When the three programs of exercise were compared statistically, the DeLorme-Watkins method was superior in the production of muscular hypertrophy to the traditional bulk program and the difference was significant beyond the 1 percent level of confidence at both the 4-inch and 8-inch levels, and was also

TABLE 2.—ANALYSIS OF VARIANCE BETWEEN DELORME-WATKINS, TRADITIONAL BULK AND TRADITIONAL STRENGTH METHODS OF PROGRESSIVE RESISTANCE EXERCISE

	No. of Cases	t Ratio	P Value
10 RM	80	9.77	.005[b]
1 RM	80	2.041	[a]
4 inch	80	13.2	.005[b]
8 inch	80	22.44	.005[b]

[a] No significance
[b] Beyond 1 percent level

superior in the same regard to the traditional strength program and was significant just beyond the 5 percent level of confidence at the 4-inch level and beyond the 1 percent level. There was no significant difference in the mean gains between the traditional bulk and traditional strength programs (Table 3).

Strength Measurements. Statistical treatment of the 1 RM (strength index) mean gains showed no significant difference between any combination of the three exercise programs. However, there was a significant difference between the DeLorme-Watkins program and the two traditional programs for the 10 RM (work load index) measurements beyond the one percent level of confidence. Again there was no significant difference of mean gains between the two traditional exercise programs for the 10 RM measurements.

Conclusions

All three programs of exercise produced great strength gains, nearly 60 percent increase in the weight a man can lift through complete range of motion in horizontal knee extension in the eight-week training period.

The two traditional programs produced basically the same results in production of strength increase and absence of production of hypertrophy. From this study it is apparent that the traditional bulk or hypertrophy program does not achieve the specific results for which it was recommended, at least in eight weeks. Also the Macqueen claims (see Purpose) are not substantiated in this study.

The DeLorme-Watkins program produced strength gains to nearly the same extent as the traditional programs, but also caused a significant pro-

TABLE 3.—A COMPARATIVE SUMMARY OF THE RESULTS BETWEEN THREE PROGRAMS OF RESISTANCE EXERCISE

	No. of Cases	10 RM		1 RM		4-inch		8-inch	
		t Ratio	P Value	t Ratio	P Value	t Ratio	P Value	t Ratio	P Value
Traditional Bulk vs. Traditional Strength	33	1.0424	.30	[a]	[a]	.85	.40	1.0	.30
Traditional Bulk vs. DeLorme	65	4.6349	.001[b]	[a]	[a]	.75	.001[b]	5.0	.001[b]
Traditional Strength vs. DeLorme	62	3.3194	.001[b]	[a]	[a]	2.16	.038	5.5	.001[b]

[a] No significance
[b] Beyond 1 percent level

duction of hypertrophy. This is significant in treating athletic injuries in their rehabilitation phase where atrophy is present.

Hypertrophy change or its absence was nearly the same at both the 4-inch and 8-inch levels. However, there was a slightly greater mean gain at the 4-inch level than at the 8-inch level, most likely due to the greater functional change in the vastus medialis (which has its belly near the 4-inch level) than the other components of the thigh. This functional change was the extremely important role the vastus medialis plays in the last 15 deg. of extension under maximum load. Ordinarily in normal use this muscle is not taxed to the extent of the other quadriceps muscles.

The DeLorme-Watkins program is superior to the traditional program when both increased strength and hypertrophy are desired.

The strength increase in all three programs was gradual throughout the eight-week exercise period.

Recommendations

It is recommended from this study that:

1. The DeLorme-Watkins program of exercise be used where both hypertrophy and strength are desired.
2. The traditional bulk or strength programs of exercise be used where only strength is considered and there is no injury, or where performance calls for increased strength without increased muscle mass. This is desirable for increased efficiency in muscular performance.
3. A program of heavy resistance exercise be used where increased performance is required for a given task. That is to say, all athletic teams such as football, basketball, track, etc., could benefit greatly from specifically organized programs of PRE for increased performance and prevention of athletic injuries.
4. Further study be undertaken to investigate refinement of the techniques of PRE in regard to the number of repetition, duration, and intensity of exercise program.

References

1. Barney, Vermon S. *A Comparison of the DeLorme Technique of Progressive Resistance Exercise with a Modified Technique.* Master's thesis. Provo: Brigham Young University, 1956.
2. DeLorme, T. L. "Heavy Resistance Exercise." *Archives of Physical Medicine* 27: 607-30: October 1946.
3. DeLorme, T. L., and Watkins, A. L. *Progressive Resistance Exercise.* New York: Appleton-Century-Crofts, Inc., 1951.
4. McMorris, Rex A., and Elkins, Earl C. "A Study of Production and Evaluation of Muscular Hypertrophy." *Archives of Physical Medicine* 35: 420-26; July 1954.
5. Macqueen, I. J. "Recent Advances in the Technique of Progressive Resistance Exercise." *British Medical Journal* 20, No. 4898: 1181-93; November 1954.

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Changes in the Serum Cholesterol Levels of Male College Students Who Participated in a Special Physical Exercise Program[1]

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Abstract

This study attempted to determine the possible changes in the serum cholesterol levels of male college students who participated in a vigorous physical exercise program, as conducted in a college physical education class. The two parallel groups of male freshman college students who served as subjects were considered to have "low fitness" and a relatively high level of serum cholesterol. The control group participated in no physical education classes nor strenuous recreational activities while the exercise group was in a special physical education class which met for 35 minutes three times a week over a ten-week period. Although the exercise group improved significantly more in physical fitness than the control group, the difference between the final serum cholesterol levels of the two groups was not significant.

MAN'S QUEST for longevity is at present being thwarted, to a considerable degree, by cardiovascular diseases, which are the leading causes of death in the United States. Atherosclerosis appears to be one of the most important of these diseases, since it has been designated by many as the chief cause of coronary heart disease and cerebral vascular disease. An important characteristic of atherosclerosis is the presence of an unusually large amount of cholesterol in the blood serum of many of the affected persons. Investigators have indicated that physical inactivity, among many other factors, may contribute to this abnormal condition. If this is true, then an improved physical fitness level might be accompanied by a decreased serum cholesterol level. This was the hypothesis upon which this study was based.

Purpose

The purpose of this study was to determine the possible changes in the serum cholesterol levels[2] of male college students who participated in a

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[1]This study was made in partial fulfillment of requirements for the degree of Doctor of Philosophy at the University of Oregon, 1959, under the direction of P. O. Sigerseth. It was financed in part by a research grant from the Graduate School of the University of Oregon to P. O. Sigerseth, and in part by a grant from the Oregon Heart Association to the author.

[2]Whenever the term "serum cholesterol level" is used, it refers to the total cholesterol level—that found in both the free and esterified forms—and is reported in terms of milligrams per 100 milliliters.

vigorous (according to physical education class standards) physical exercise program throughout the ten weeks of one university term. The exercise program was a Developmental Physical Education class at the University of Oregon which met for 35 minutes, three times a week. The subjects were considered to be a "low fitness" group in terms of their physical condition at the beginning of the investigation.[3] Because of this, it was felt that they would benefit physically from the conditioning program. Another factor pertinent to the hypothesis was that the mean serum cholesterol levels of the two groups in the beginning were approximately 200mg./100ml. which was regarded as being "above normal." This assumption was based upon the work of Keys (4) who found that the normal level for 18-year-old males was approximately 170mg./100ml. and that a level of 200mg./100ml. would be one standard deviation above this mean level.

Review of Literature

While a great many studies have been reported in the past decade that have dealt with the role of cholesterol in man, comparatively few of the investigations have been concerned with determining the relationship of the level of physical fitness to the serum cholesterol level. This review will deal only with those studies which are directly related to the purpose of this study. For a more complete listing of information regarding cholesterol, attention is directed to Pohndorf (11) and Hein and Ryan (3).

The earliest study reported was by Chailley-Bert and others (1). One part of the study indicated that active subjects had substantially lower serum cholesterol levels than sedentary subjects. A second part provided evidence that sedentary individuals could lower their serum cholesterol levels by becoming physically more active.

Procedure

The subjects in this study were 40 freshman students from the University of Oregon. They ranged in age from 18 to 24 years. All failed the University's physical fitness test which was given to them during Freshman Week

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[3]The term "physical fitness" was interpreted, in this study, as including those factors which are purported to be measured by the two tests used in the investigation—The Physical Fitness Index and the Air Force Physical Fitness Test.

Mann and others (6) found that when students doubled their caloric intake, there was no change in serum cholesterol levels if they exercised enough to keep their weights normal. Without the exercise, however, their serum cholesterol levels doubled in a three-week period.

Keys and colleagues (5) reported that the serum cholesterol levels of men who exercised after eating were reduced, while the levels of those who were inactive, increased. However, Taylor and others (13), in a somewhat similar study, found no significant differences in the subjects' serum cholesterol levels.

Pohndorf (10) reported finding significant changes in the serum cholesterol levels of his subjects. The cholesterol decreases closely paralleled increases in physical fitness as determined by a number of different tests. A study made at Michigan State University (7,8), however, found no significant changes in the serum cholesterol levels in either of two groups of subjects. This occurred in spite of the fact that the exercise group showed a material improvement in its physical fitness level. It was pointed out, however, that three subjects who had high serum cholesterol levels initially did have levels following the exercise period which were appreciably decreased.

of the 1957-58 school year.[4] All volunteered to take part in the study, and medical examinations, which the students had to provide to enter the University, revealed no illnesses or body malfunctions which would interfere with their participation in the study. All lived and ate regularly in one of the University's dormitories. None took part in interschool sports during the fall term, and all those selected as members of the control (nonexercise) group agreed to limit their physical activity.

From an original group of 57 volunteers, two parallel groups of 20 subjects each completed the experiment. These groups were equated on the basis of their original serum cholesterol levels. The members of the groups were also paired on the basis of similar physical fitness test scores, deviations from normal weight, and chronological age.

The control group participated in no physical education classes, intramural games, intercollegiate athletic contests, or vigorous recreational activities of any type during the ten-week experimental period. These students were members of a class in personal health, a subject required of all University of Oregon students. This class, which met twice a week for 50 minutes each period, was taught by the investigator.

The subjects in the exercise group were members of a Developmental Physical Education class which was also taught by the author during this same school term. The students in this class had 35 minutes of vigorous activity on Mondays, Wednesdays, and Fridays of each week. The following activities, utilized in this order, were the basis of the work in this class:

1. The U.S. Army Conditioning Exercise Drill No. 1 (9). The students began by doing six repetitions of the 12 calisthenic exercises which make up this drill and gradually increased the number of repetitions until they were doing 13 repetitions at the end of the term.
2. Running. The subjects ran and jogged 440 yds. in the first week's classes and gradually increased the distance until they were running a distance of 740 yds. at the end of ten weeks.
3. Weight lifting. The subjects performed as many repetitions as possible of each of the following common lifts during the last five minutes of each period: Military Press, Full Squats, and Rowing Exercise.

Because it was known that diet materially affects the serum cholesterol level, a check was made of every item of the food eaten by each subject during six selected days of the study. This was facilitated by the fact that each subject ate his meals in a University dormitory dining room, and the food served at these meals was prepared in a central kitchen. By means of these checks, it was possible to compute the average caloric intake and the average number of grams of fat consumed daily by each subject. These data were then analyzed to determine if there were any significant dietary differences between the two groups.

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[4]The test used at the time was Rogers' Physical Fitness Index and a score of less than 85 points was considered a failure.

The serum cholesterol levels at both the beginning and the end of the study were determined on the basis of an analysis of two separate samples of blood (ten cubic centimeters each time) drawn several days apart. The blood samples were taken in the morning before the subjects had eaten their breakfasts. The cholesterol level was determined by means of the Zak or ferric-chloride method (14). As a check to avoid using subjects who had an abnormal metabolic condition, the seven subjects who had serum cholesterol levels above 230mg./100ml. were given the Protein Bound Iodine test. All were found to be normal.

Results

To determine the similarity of the groups, it was necessary to analyze the data gathered at the beginning of the study, which represented the serum cholesterol level, degree of physical fitness, weight and age of the subjects. A comparison of the means of these data, as presented in Table 1, showed no significant differences between the groups. The method used to determine the reliability of these differences was the one given by Garrett (2) for use with groups matched for mean and standard deviation. A comparison of the standard deviations also revealed no significant differences in the variability of the groups in regard to the same data.

An analysis of the total amount of food consumed by each subject during each of the six selected days of the study disclosed that, on the average, the students in each group had eaten approximately the same number of calories (2936) of food per day. It was further found that the mean daily consumption of fats by members of the two groups was so similar that the difference of 2.4 grams was insignificant. The t value for this difference was .31, while a value of 2.09 was necessary to indicate significance at the 5 percent level of confidence.

The results of the retesting done at the conclusion of the experiment, when compared with the initial findings, revealed two significant changes which had occurred within the groups. The reliability of these differences was ascertained by using the difference method which Garrett indicated as

TABLE 1.—DIFFERENCES BETWEEN THE MEANS OF THE TWO GROUPS AT THE BEGINNING OF THE STUDY

N 20 df 19

Variable	Mean of Control Gp.	Mean of Exercise Gp.	Mean Dif.	S.E. of Dif.	t[a]
Serum Cholesterol	200.75	199.20	1.55	2.13	.73
PFI Test	73.70	73.90	.20	3.83	.05
Air Force Test	42.20	41.20	1.00	3.24	.31
Weight Deviation	+8.15	+9.00	.85	3.49	.25
Chronological Age	18.80	18.80	.00	.00	.00

[a] t values necessary to show significance:
5 percent level of confidence = 2.09
1 percent level of confidence = 2.86

being preferable when the number of subjects in the groups is small. A comparison of the mean scores for the control group, as shown in Table 2, disclosed a decrease in the serum cholesterol level which was significant at the 5 percent level of confidence and an increase in the Physical Fitness Index test score which was significant at the 1 percent level of confidence. The data from the Air Force Test and Weight Deviation records showed no significant differences.

A comparison of the beginning and final mean scores for the exercise group, indicated in Table 3, showed that the physical fitness level of the group was significantly increased. The final Physical Fitness Index test score was 21.25 points better and the Air Force Physical Fitness test score was 14.75 points better. There was no significant change in the serum cholesterol level of the exercise group. Although the final level was slightly lower than the beginning level, the decrease of 3.7mg./100ml. was considerably less than that necessary to be significant.

An inspection of the individual subject's serum cholesterol changes at the completion of the experiment revealed no discernible pattern of change. Some of the subjects had final levels that were lower than their initial levels, but almost as many completed the experiment with increased choles-

TABLE 2.—CHANGES IN THE STATUS AND PERFORMANCES OF THE CONTROL GROUP

N 20 df 19

Variable	Mean at Beginning	Mean at End	Mean Dif.	S.E. of Dif.	t[a]
Serum Cholesterol	200.75	189.85	−10.90	4.50	2.42
PFI Test	73.70	79.20	+ 5.50	1.72	3.19
Air Force Test	42.20	43.65	+ 1.45	1.23	1.18
Weight Deviation	+8.15	+7.40	− .75	.58	1.29

[a] t values necessary to show significance:
5 percent level of confidence = 2.09
1 percent level of confidence = 2.86

TABLE 3.—CHANGES IN THE STATUS AND PERFORMANCES OF THE EXERCISE GROUP

N 20 df 19

Variable	Mean at Beginning	Mean at End	Mean Dif.	S.E. of Dif.	t[a]
Serum Cholesterol	199.20	195.50	− 3.70	3.76	.98
PFI Test	73.90	95.15	+21.25	1.98	10.73
Air Force Test	41.20	55.95	+14.75	1.31	11.26
Weight Deviation	+9.00	+8.65	− .35	.43	.81

[a] t values necessary to show significance:
5 percent level of confidence = 2.09
1 percent level of confidence = 2.86

terol levels. This was true for those who had serum cholesterol levels of above 200mg./100ml. as well as for those who had levels below this point.

The concluding step in the analysis was to ascertain how the control group compared with the exercise group at the end of the investigation. This, also, was done by applying the method given by Garrett for groups matched for mean and standard deviation. Table 4 reveals that the groups were significantly different at the end of the experiment only in physical fitness as

TABLE 4.—DIFFERENCES BETWEEN THE MEANS OF THE TWO GROUPS AT THE END OF THE STUDY

N 20 df 19

Variable	Mean of Control Gp.	Mean of Exercise Gp.	Mean Dif.	S.E. of Dif.	t[a]
Serum Cholesterol	189.85	195.50	5.65	8.59	.66
PFI Test	79.20	95.15	15.95	2.76	5.78
Air Force Test	43.65	55.95	12.30	2.87	4.29
Weight Deviation	+7.40	+8.65	1.25	3.23	.39

[a] t values necessary to show significance:
5 percent level of confidence = 2.09
1 percent level of confidence = 2.86

measured by the two tests. The exercise group made the higher scores on both of the tests. The serum cholesterol levels of the two groups, although differing more on the final tests than on the initial tests, were not significantly different. This can be explained in part by the fact that in the beginning there was a high correlation (.95) between the serum cholesterol levels of the matched pairs, while at the end of the study the coefficient of correlation between them was only .58. The lower correlation at the conclusion of the study resulted from the changed serum cholesterol levels of the individual subjects which appeared to follow no pattern.

Discussion

The findings of this study failed to support the hypothesis that an improvement in physical fitness will bring about a reduction in the serum cholesterol level of college students who are considered to be in a "low fitness" group. In the initial aspect of this study, the data seemed to support this theory since the subjects in both groups appeared to be low in physical fitness and had, as groups, above normal serum cholesterol levels. The findings at the conclusion of the study, however, revealed that the control (nonexercise) group registered a significant decrease in its serum cholesterol level, while the exercise group showed no significant change in its serum cholesterol level.

The "vigorousness" of the physical exercise program given the exercise group may be questioned by those who have studied the research in this area. It is recognized that the amount of physical activity demanded of the subjects in this study was not as great as that reported in other studies. The

design of this study, however, was to determine the possible changes in the serum cholesterol of the subjects who participated in an exercise program in a normal physical education situation. That the physical education program accomplished its physical fitness objective can be judged by noting the significant improvement in physical fitness, as recorded by the test results, made by the exercise group.

It might be argued that the personal health class which the control group took was responsible for the unexpected outcome of this study. While the sections dealing with the circulatory system and the beneficial effects of exercise were purposely postponed until the last three weeks of the term, it is certainly understandable that the students could have gained knowledge which may have affected their behavior which, in turn, may have brought about a change in their serum cholesterol levels.

Dietary differences could also account for the decrease of the serum cholesterol level of the control group. It is recognized that the controls and checks used in this investigation were of a minimum nature and thus, perhaps, inadequate for a study in which diet could play such an important role. Thus the control group could have had a diet which was more conducive to a decreased serum cholesterol level. This is suggested despite the evidence to the contrary which was reported.

It also should be noted that perhaps more than two samples of blood should have been drawn in determining the serum cholesterol levels. Many of the earlier studies, however, utilized no more than this number, and to have taken more would have been difficult in this situation.

The length of the study could have had a material influence on the results. If the investigation could have continued for a full school year, perhaps the control group's serum cholesterol level would have stabilized, while the exercise group's level would slowly decline.

Finally, it is recognized that other, uncontrollable factors such as the stress occurring from mental and emotional problems could have had a substantial effect upon the outcome of this investigation, thus making a simple explanation of the results extremely difficult.

Conclusion

It would appear that a regular, vigorous physical exercise program, as used in this study and as may be given in the physical education department of a college or university, had no predictable effect upon the serum cholesterol levels of young men of college age who were considered below normal in physical fitness and above normal in serum cholesterol levels at the beginning of the investigation.

References

1. Chailley-Bert, Labignette, Pierre, and Fabre-Chevalier. "Contribution a l'Etude des Variation du Cholesterol Sanguin au Cours des Activities Physiques." *La Press Medicale* 63:21; March 13, 1955.
2. Garrett, Henry E. *Statistics in Psychology and Education.* 4th edition. New York: Longmans, Green and Co., 1953.

3. HEIN, FRED V., and RYAN, ALLAN J. "The Contributions of Physical Activity to Physical Health." *Research Quarterly* 31:263; May 1960.
4. KEYS, ANCEL. "The Age Trend of Serum Concentrations of Cholesterol and of Sf 10-20 ('G') Substances in Adults." *Journal of Gerontology* 7:201; April 1952.
5. KEYS, ANCEL, ANDERSON, JOSEPH T., and MICHELSEN, OLAF. "Serum Cholesterol in Men in Basal and Nonbasal States." *Science* 123:29; January 6, 1956.
6. MANN, GEORGE V., ET AL. "Exercise in the Disposition of Dietary Calories—Regulation of Serum Lipoprotein and Cholesterol Levels in Human Subjects." *New England Journal of Medicine* 253:349; September 1955.
7. MONTOYE, HENRY J., ET AL. "The Effects of Exercise on Blood Cholesterol in Middle-Aged Men." *American Journal of Clinical Nutrition* 7:139; March-April 1959.
8. OLSON, H. W. "The Effect of a Supervised Exercise Program on the Blood Cholesterol of Middle-Aged Men." *Physical Educator* 15:135; December 1958.
9. *Physical Training.* Department of the Army Field Manual 21-20. Washington: United States Government Printing Office, 1950.
10. POHNDORF, RICHARD H. "The Improvement in Physical Fitness of Two Middle-Aged Adults." Doctoral dissertation, Urbana: University of Illinois, 1957.
11. POHNDORF, R. H. "Cholesterol Studies: A Review." *Research Quarterly* 29:180; May 1958.
12. PRYOR, HELEN B. *Width-Weight Tables.* 2nd edition. Stanford: Stanford University Press, 1940.
13. TAYLOR, HENRY L.; ANDERSON, JOSEPH T.; and KEYS, ANCEL. "Effect on Serum Lipids of 1300 Calories of Daily Walking." *Federation Proceedings* 15:128; March 1957.
14. ZAK, B., ET AL. "Rapid Estimation of Free and Total Cholesterol." *American Journal of Clinical Pathology* 24:1307; November 1954.

(Submitted 4/28/60)

Scholastic Achievement of Boys 9, 12, and 15 Years of Age as Related to Various Strength and Growth Measures[1]

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Abstract

The experimental design used in this study consisted of forming a series of high and low scoring groups of 20 boys each separately on the basis of three strength and two growth measures at each age, 9, 12, and 15 years; each pair of high and low groups was equated by use of intelligence quotients. The academic achievements of the groups were then contrasted. A consistent and significant tendency for the high groups to have higher means on both standard achievement tests and grade point averages was noted. There were more and greater differences in scholastic achievement between the high and low Physical Fitness Index groups than there were for the other strength and growth measures compared. The Strength Index was especially effective at nine years of age. For each of the other experimental variables, Rogers' arm strength score, McCloy's Classification Index, and Wetzel's developmental level, significance between means on academic measures was achieved once only.

ASSOCIATED WITH THE concept that physical fitness is a human quality basic to the meeting of life's problems is the belief held by some that a physically vigorous and enduring body improves the effectiveness of the individual's mental capabilities. For example, as a result of observing low fitness individuals for many years, Rogers (12) maintained that physically unfit boys and girls at all levels of intelligence have greater difficulty in continuing mental effort and remaining mentally alert. He also contended that the potential for learning depends upon both intelligence and physical fitness. This could be interpreted to mean that a person's learning potential for a given level of intelligence is increased or decreased in accordance with his or her level of physical fitness.

[1] This study was conducted with data from the Medford, Oregon, Boys' Growth Study. Subsidization of the Growth Study was provided by Medford Public Schools, Southern Oregon College, Athletic Institute (Chicago, Ill.), Oregon State Education Department, and University of Oregon. Acknowledgments for testing assistance are made to the following University of Oregon graduate and Southern Oregon College undergraduate students: Dale Bates, David H. Clarke, James C. E. Harrison, Noel R. Hayman, Ronald Mauer, Kay H. Petersen, and J. Stuart Wickens. The superintendent of the Medford Schools, Leonard A. Mayfield, and the director of physical education, Lee Ragsdale, as well as Theodore Schopf, of Southern Oregon College, are also especially recognized for their assistance.

With these considerations in mind, this study was undertaken to determine the relationships between the academic achievement of boys and certain growth and physical measures. The study was limited to boys 9, 12, and 15 years of age.

Related Literature

A number of researches support the contention that physical fitness is related to mental achievements. After 25 years of studying intellectually gifted children, Terman (16) stated that: "The results of the physical measurements and medical examinations provide a striking contrast to the popular stereotype of the child prodigy, so commonly predicted as a pathetic creature, over-serious, undersized, sickly, hollow-chested, nervously tense, and bespectacled. There are gifted children who bear some resemblence to this stereotype, but the truth is that almost every element in the picture, except the last, is less characteristic of the gifted child than of the mentally average." In Terman's initial study (15), when his gifted subjects were young, symptoms of general weakness were reported by the school nearly 30 percent less frequently for the gifted than for the control group.

As reported by Brace (2), studies in Manchester, England, revealed that only 2.35 percent of students who were above average in scholarship were below average in physique as evidenced by body measurements, but that 39.7 percent with poor scholarship were below average in physique. In Brace's report, Christopher, who examined 33,500 school children in St. Louis, found that dull children were generally lighter and bright children were generally heavier than average children and that intellectual mediocrity was associated with physical mediocrity.

In 1922, Rogers (13) studied two groups of college men with nearly equal intelligence quotient averages but differing greatly in average muscular strength. The scholarship of the high strength group (IQ mean of 107) was considerably higher than that of the low strength group (IQ mean of 111). Rarick and McKee (10) studied the scholastic capabilities of two groups of third grade children; one group scored high and the other scored low in motor proficiency. They reported that the superior motor performance group demonstrated better scholastic adjustment, as evidenced by the larger number with high intelligence and excellent or good ratings in reading, writing, and comprehension.

Page (8) found that 83 percent of the freshman male students dismissed from Syracuse University in 1940 because of low grades had Physical Fitness Indexes below the national average of 100; 39 percent of these students had Physical Fitness Indexes below 85 (the national first quartile score). These students had mental aptitude scores on standard tests well above the average; the median aptitude score for this group was at the 72nd percentile. Coefield and McCollum (4) found that the 78 male freshmen at the University of Oregon with the lowest Physical Fitness Indexes during the 1954 fall term were definitely low in scholastic accomplishment, as compared with all men at the University. These same low fitness students, however, were superior to the other freshmen in scholastic aptitude.

In the 1941 annual report for the Brookline, Massachusetts, public schools (11), the average Physical Fitness Index for the 126 boys whose names appeared on the high school scholarship role was 117, exceeding the national third quartile of 115. In a study of sophomore high school boys, Popp (9) found that eight of the 20 boys with the lowest Physical Fitness Indexes did not graduate from high school; only two of the 20 boys with highest Physical Fitness Indexes failed to graduate from high school.

In studying cadets at the United States Military Academy, Appleton (1) found no significant relationship between entrance physical ability and scholastic success as measured by academic grades among those cadets who were successful in continuing at the Academy past the first year. However, he did find that physical proficiency tests were useful predictors of the nonacademic aspects of military success. This was particu-

larly true among those who were in the lower range of motor fitness; 90 percent of applicants in the bottom 10 percent on these tests made below average cadets.

Some studies have reported little or no relationship between physical measures and mental achievement. These investigations, however, were correlational in nature and did not allow for variances in the intelligence of the subjects. By contrast, studies showing positive physical-mental relationships either considered only those at a low fitness level or compared high and low physical groups equated in accordance with the intelligence of the subjects.

Procedure

SUBJECTS

The subjects for this study were 217 white male students in the public schools of Medford, Oregon. The numbers selected at random from the three age groups were as follows: 73 at 9 years, 75 at 12 years, and 69 at 15 years. Physical tests were administered within two months of each boys' birthday. All testing was completed during the 1956-57 academic year.

ACADEMIC ACHIEVEMENT AND INTELLIGENCE MEASURES

The intelligence tests used to equate the high and low scoring groups for each of the strength and growth tests, and the tests used to determine the academic achievement and ability of the subjects were as follows:

Otis Self-Administering Test of Mental Ability. This test (7) was designed to predict the rate at which a student can progress through school; thus, the test score is considered to be an intelligence quotient, or IQ. The Intermediate Form of this test was used for the 15-year-old boys.

California Test of Mental Maturity. This test, designed by Sullivan, Clark, and Tiegs (14), is a diagnostic test of mental maturity used to evaluate the mental abilities related to or determining an individual's success in various types of activities. It yields three achievement scores and three IQ scores, one each for language, nonlanguage, and a total score. The total scores for both achievement and IQ were used for the 9- and 12-year-old boys.

Iowa Silent Reading Test (New Edition). At 15 years of age, the Iowa Silent Reading Test, devised by Greene, Jorgensen, and Kelly (5), was used. It is intended to evaluate the following three reading abilities: (a) rate of reading at a controlled level of comprehension; (b) comprehension of words, poetry, paragraphs, sentences, and larger articles; and (c) use of skills for locating information.

Grade Point Averages. In this study, grade point averages were based on the following point system: A, four points; B, three points; C, two points; D, one point; F, zero. The grades earned by each subject during the last full semester before he was tested in this study were utilized.

The Otis Self-Administering Test of Mental Ability, the California Test of Mental Maturity, and the Iowa Silent Reading Test were administered to the subjects as a regular part of the Medford schools' testing program.[2] The academic grades were obtained from records kept in the principal's office at each of the schools.

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[2] Acknowledgment is made to Louise Basford, supervisor of testing in the Medford public schools, under whose direction this testing was done.

EXPERIMENTAL VARIABLES

Three strength and two other physical measures were used as experimental variables in this study. These measures, together with reasons for their selection, are briefly presented below.

Rogers' Strength Index. Rogers' Strength Index (3) is derived as a sum of the following battery of test items: arm strength (based on pull-ups and push-ups), right and left grips, back and leg lifts, and lung capacity. This test was selected because it is primarily a gross measure of strength (lung capacity, of course, is not a strength measure although it is included in the Rogers battery).

Physical Fitness Index. The Physical Fitness Index (3) is derived by dividing the obtained Strength Index by a norm based on the boy's weight and age. This test, therefore, was included as a measure of relative strength.

Rogers' Arm Strength. Rogers' arm strength (3) is computed from the following formula:

$$(.1 \text{ Weight} + \text{Height} - 60)\ (\text{Pull-ups} + \text{Push-ups}).$$

An arm strength test was selected as an experimental variable, because it is related specifically to an area of generally acknowledged muscular weakness of boys, the strength of the arms and shoulder girdles; also, arm strength measures are important components of many strength, motor fitness, and motor ability test batteries.

McCloy's Classification Indexes (6). McCloy's Classification Index III was used for the 9-year-old boys: 10 (age) + weight. For the 12- and 15-year-old boys, his Classification Index I was used: 20 (age) + 6 (height) + weight. This test was included because of its effective combination of the essential growth measures of age, height, and weight.

Wetzel Developmental Level. The Wetzel Grid (17) provides a method of evaluating the physical status and progress of an individual by use of two connecting graph patterns upon which age, height, and weight data are plotted. The grid attempts to determine the child's physique channel in terms of his size and shape. The developmental level, the factor utilized in this study, indicates the boy's body development as related to his type of body build; this level on the grid increases at a rate of approximately one level per month.

FORMING EXPERIMENTAL GROUPS

For each experimental variable at each age, two groups of 20 boys were formed in the following manner. Two subjects were selected at a time; these subjects had IQ's as nearly equal as possible, but one had a high score and the other had a low score on a given experimental variable. Thus, in each instance, high and low scoring groups on the strength and growth measures were established, with the groups being equated by intelligence quotients. This process was repeated 15 times, once at each of the three age levels for each of the five experimental variables. The 20 subjects selected and placed in each group equaled approximately 25 percent of the boys available at each age.

Results

COMPARISON OF EXPERIMENTAL GROUPS

To show the degree the groups were equated by intelligence quotients, the mean and standard deviations for each equational operation were computed. The differences between these means and standard deviations

were tested for significance by application of the t ratio. The t's for the difference between the IQ means appear in the left half of Table 1.

The differences between the IQ means for the 15 equations were low. The greatest difference between any of the pairs of means was 1.25 IQ points for the Classification Index equation at 15 years of age. This equation also had the highest t ratio (.38), which, however, is far from significant at

TABLE 1.—TESTS OF SIGNIFICANCE BY APPLICATION OF t RATIOS TO SHOW EQUATION OF EXPERIMENTAL GROUPS

Experimental Variable	t Ratios Between Means: Intelligence Quotients			t Ratios Between Means: Experimental Variables		
	9 yrs.	12 yrs.	15 yrs.	9 yrs.	12 yrs.	15 yrs.
Strength Index	.00	.15	.00	10.05	11.32	10.19
Physical Fitness Index	.21	.07	.25	10.94	16.80	11.24
Rogers' Arm Strength	.08	.22	.09	11.10	12.97	12.00
McCloy's Classif. Index	.18	.13	.38	10.00	8.72	9.98
Wetzel Dev. Level	.17	.16	.07	11.48	10.85	9.27

any acceptable level of confidence. Although the t ratios for the differences between the standard deviations are not included in the table, they followed much the same pattern as for the differences between means. The highest t ratio was .81 for the Classification Index equation at 12 years of age.

To determine the success of dividing the subjects into high and low groups, the means of the experimental variables were computed and tested for significance. The t's for the differences between these means are given in the right half of Table 1. The most significant difference between these means was for the Physical Fitness Index at age 12, since this comparison had the highest t ratio of 16.80. The lowest t ratio was 8.72 for McCloy's Classification Index at 12 years of age. In all instances, therefore, the differences between the groups on the experimental tests were significant far beyond the .01 level.

As a final check on the adequacy of the various equations, a comparison of the range of scores on the experimental variables was made. It was felt that too great heterogeneity might result in an undesirable overlapping of the high and low groups. An examination of the ranges disclosed that in no instance was such overlapping present. In fact, for each variable, a definite gap existed between the lowest score of the high group and the highest score of the low group.

As a consequence of these comparisons, it may be concluded with considerable assurance that the different groups of 9-, 12-, and 15-year-old boys were adequately equated insofar as their intelligence quotients were concerned. In each instance, the subjects were divided into distinct high and low performance groups on the basis of their scores on the experimental test variables.

ACADEMIC ACHIEVEMENT RESULTS

A summary of the t ratios for the difference between the means on academic performance for the high and low groups is presented in Table 2. For these comparisons, t's of 2.00 and 2.69 are significant at the .05 and .01

TABLE 2.—TESTS OF SIGNIFICANCE BY APPLICATION OF t RATIOS TO SHOW DIFFERENCES IN MEAN ACADEMIC PERFORMANCE

Experimental Variable	Achievement Tests			Grade Point Average		
	9 yrs.	12 yrs.	15 yrs.	9 yrs.	12 yrs.	15 yrs.
Strength Index	3.00	.83	.13	5.69	1.53	1.10
Physical Fitness Index	2.31	.19	.03	.94	3.14	2.00
Rogers' Arm Strength	.76	.85	.33	1.94	1.21	2.19
McCloy's Classif. Index	2.06	1.17	1.85	1.84	.56	1.20
Wetzel Dev. Level	.83	1.07	2.22	1.67	1.27	.85

levels respectively. The conclusions which may be drawn from this table, supplemented by a study of the varous means as they appeared in the study, are as follows:

1. Throughout the study, a consistent tendency was found for the high groups on the experimental strength and growth tests to have higher means on both the standard achievement tests and in grade point averages. In all instances of significant differences, the means of the high groups were larger than those of the low groups on the experimental tests. However, no consistent pattern was found in which the same tests had significant differences at all ages and for both achievement tests and grade point averages.

2. There were more and greater differences in scholastic achievement between the high and low Physical Fitness Index groups than there were for the other strength and growth measures compared. It was the only test in which significant differences were found at each of the three ages. A t of 2.31 was obtained for the difference between means on the standard achievement test at nine years of age; t's of 3.14 and 2.00 were obtained for the differences between means in grade point averages at 12 and 15 years of age.

3. Rogers' Strength Index was particularly effective in differentiating levels of academic performance at nine years of age; t's of 3.00 and 5.69 were obtained for the differences between means on the academic achievement test and in grade point average respectively.

4. The differences between means for the McCloy Classification Index groups reached significance at the .05 level of confidence in one instance and nearly reached this level in two others. The t's were 2.06 and 1.83 for the standard achievement tests at ages 9 and 12 years and 1.84 for grade point average at 9 years of age.

5. The t's for Rogers' arm strength score as applied to grade point averages were fairly high, reaching significance at the .05 level at 15 years of age ($t = 2.19$) and nearly reaching this level of significance at 9 years of age ($t = 1.94$).

6. Significance was found only once with the Wetzel developmental level. This was for the standard achievement test scores at 15 years of age ($t = 2.22$).

7. For the different ages, least significance among the experimental variables was found at 12 years. The only significant t was 3.14 for the Physical Fitness Index as applied to grade point averages.

Summary

The experimental design used in this study consisted of forming a series of high and low scoring groups of 20 boys on the basis of three strength and two growth measures. Each pair of high and low groups was equated by use of intelligence quotients. The academic achievements of the groups were then contrasted and the differences between their means were tested for significance. This process was repeated 15 times, once at each age, 9, 12, and 15 years, for each of the five experimental variables.

There was a consistent tendency for the high groups on the experimental variables to have higher means on both academic achievement tests and grade point averages; the differences between means, however, were not always significant. The best differentiation between good and poor performances on the academic achievement measures was obtained with the Physical Fitness Index. Rogers' Strength Index was especially effective at nine years of age. For the different ages, least significance among the experimental variables was found at 12 years, with the Physical Fitness Index only being significant when applied to grade point averages.

References

1. Appleton, Lloyd O. "The Relationship Between Physical Ability and Success at the U.S. Military Academy." Microcarded Doctoral dissertation, New York University, 1949.
2. Brace, David K. "Some Objective Evidence of the Value of Physical Education." *Journal of Health and Physical Education*, 4: 36; April 1933.
3. Clarke, H. Harrison. *Application of Measurement to Health and Physical Education*. 3rd Edition. Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1959.
4. Coefield, John R., and McCollum, Robert H. "A Case Study Report of Seventy-eight University Freshmen Men with Low Physical Fitness Indices." Microcarded Master's Thesis, University of Oregon, 1955.
5. Greene, H. A.; Jorgensen, A. N.; and Kelley, V. H. *Iowa Silent Reading Test*. New Edition. Yonkers-on-Hudson, N. Y.: World Book Co., 1943.
6. McCloy, Charles H. *Measurement of Athletic Power*. New York: A. S. Barnes Co., 1932.
7. Otis, Arthur S. *Otis Self-Administering Test of Mental Ability*. Yonkers-on-Hudson, N. Y.: World Book Co., 1928.
8. Page, C. Getty. "Case Studies of College Men with Low Physical Fitness Indices." Master's thesis, Syracuse University, 1940.
9. Popp, James. "Case Studies of Sophomore High School Boys with High and Low Physical Fitness Indices." Microcarded Master's thesis, University of Oregon, 1959.
10. Rarick, Lawrence G., and McKee, Robert. "A Study of Twenty Third Grade Children Exhibiting Extreme Levels of Achievement on Tests of Motor Efficiency." *Research Quarterly* 20: 142; May 1949.

11. "Report of the School Committee and Superintendent of Schools of Brookline, Massachusetts," December 31, 1941.
12. ROGERS, FREDERICK R. "Rogers' Law of Learning Capacity." *Physical Fitness News Letter*, School of Health and Physical Education, University of Oregon, January, 1955.
13. ROGERS, FREDERICK R. "The Scholarship of Athletes." Master's thesis, Stanford University, 1922.
14. SULLIVAN, ELIZABETH T.; CLARK, WILLIS W.; and TIEGS, ERNEST W. *California Test of Mental Maturity*. Los Angeles: California Test Bureau, 1951.
15. TERMAN, LEWIS M., Editor. *Genetic Studies of Genius I. Mental and Physical Traits of a Thousand Gifted Children*. Stanford, Calif.: Stanford University Press, 1925.
16. TERMAN, LEWIS M., Editor. *Genetic Studies of Genius IV. The Gifted Child Grows Up*. Stanford, Calif.: Stanford University Press, 1947.
17. WETZEL, NORMAN C. *The Treatment of Growth Failure in Children*. Cleveland: NEA Service, Inc., 1948.

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Contrast of Maturational, Structural, and Strength Characteristics of Athletes and Nonathletes 10 to 15 Years of Age[1]

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Abstract

This study contrasted maturational, structural, strength, and motor traits of upper elementary and junior high school boys with different levels of athletic ability and contrasted the same traits of boys in these athletic groups with nonparticipants. Levels of athletic ability were differentiated according to success as participants on interschool competitive teams. Such results as the following were obtained: The outstanding athletes at both school levels had significantly higher mean skeletal ages than did the other groups; in studying maturity relative to chronological age, the outstanding elementary school athletes only were found to be advanced. In general, the size of athletes as compared with nonparticipants was more significant at the junior high school than at the elementary school level; this was particularly true for the outstanding athletes. A higher proportion of mesomorphs was also found among the junior high school athletes. Strength was a consistent differentiator of athletic ability; this was particularly true for the gross measures, such as the Strength Index and the mean of 12 cable-tension strength tests. In the standing broad jump, the means of the outstanding athletes and the regular players were significantly higher than the means of the nonparticipants at both school levels.

Statement of the Problem

THE PURPOSE of this study was to contrast maturational, structural, strength, and motor traits of upper elementary and junior high school boys with different levels of athletic ability and to contrast the same traits of boys in these athletic groups with nonparticipants. Levels of athletic ability were differentiated according to the boys' success as participants on interschool competitive teams. The study does not attempt to determine the effects of such competition upon the participants.

[1] This study was conducted with data from the Medford, Oregon, Boys' Growth Study. Subsidization of the growth study was provided by the Medford Public Schools, Southern Oregon College, State Education Department, Athletic Institute, and the University of Oregon. Acknowledgments for testing assistance are made to the following University of Oregon graduate and Southern Oregon College undergraduate students: Dale Bates, David H. Clarke, James C. E. Harrison, Noel R. Hayman, Robert Irving, Boyd O. Jarman, Ronald Mauer, and J. Stuart Wickens. The superintendent of schools, Leonard A. Mayfield, and the director of physical education, Lee Ragsdale, as well as Theodore Schopf, Southern Oregon College, are also recognized for their assistance.

Related Literature

The available studies related to the effects of participation in elementary or junior high school interscholastic athletic programs have been concerned primarily with the physiological effects of strenuous activities, with the growth and development comparisons of athletes and nonathletes, and with the emotional responses of boys in competitive situaions. In this literature report, the results of representative studies only will be presented.

In 1933, Rowe (8) made a series of studies comparing the growth of athletes and nonathletes in the junior high schools of Cleveland, Ohio. In several preliminary investigations, he found that the nonathletes gained more in height and weight than the athletes. In a subsequent three-year study, he again found that the nonathletes outgained the athletes in height, weight, and lung capacity. Rowe concluded that his findings may have been influenced by the possibility that the athletes matured earlier, thereby having already completed much of their adolescent growth. Twenty-one years later, in a study of 1028 Cleveland high school boys, Krogman (6) provided support to Rowe's conclusion by revealing that the athletic group was two years advanced in skeletal age as contrasted with the nonathletic group.

Fait (2) administered the following anthropometric tests to 107 boys in three junior high schools: height, weight, chest width, bi-acromial width and bi-cristal width. Two of the schools participated in interscholastic athletics while the third did not. After a six-month period had elapsed, Fait found that in height only did the nonathletic group consistently show greater growth at all three maturational levels: prepubescent, pubescent, and postpubescent. Those who did not participate in varsity athletics grew .365 inch more than those who did; this difference was significant at the .01 level.

DeLotto (1) administered the following tests to 348 boys 9 to 12 years of age: height, weight, standing broad jump, motor educability, right and left grips, and lung capacity. These boys were divided into two groups: an experimental group of 189 boys and a control group of 159 boys. The experimental group participated in a two-hour athletic program weekly for eight months; the athletic activities were touch football, basketball, baseball, and track and field. The differences between the groups on the experimental tests were not significant.

Hale (4) studied the pubescent development, based on the Crampton pubic hair criteria, of 112 participants in the 1955 Little League Baseball World Series. Among his findings were (a) the majority of the boys were adolescent and not preadolescent, as their chronological ages would indicate; (b) all eight pitchers who started World Series games were postpubescent, except one who was pubescent; (c) the greatest number of postpubescent subjects batted in third, fourth, fifth, and sixth positions; all boys who batted in the "clean-up" position were postpubescent; (d) the height and weight of the postpubescent subjects were equal to the height and weight of the average 14-year-old boy, although their chronological ages did not exceed 12 years.

Skubic (11) contrasted the emotional responses, as measured by the galvanic skin response test, of boys between the ages of 9 and 15 years who were participants in required physical education classes and on Little League baseball teams. The results of this study included the following: (a) in the emotional response to competitive athletics, the boys were excited immediately before a game, most excited immediately after a game, and then progressed to a relaxed state; (b) at all ages, Little League players were less excitable on all tests than boys who were not members of the team; (c) no appreciable difference was found in the emotional response of boys to competition in physical education softball games, league baseball games, and all-star championship games.

In a study of 114 Little League baseball players and an equal number who did not compete in this activity, Seymour (10) found that Little League participants showed a higher degree of leadership, were accorded a higher level of social acceptance, and possessed more desirable personality traits than did the nonparticipants. Salz (9) also reported that boys who competed on Little League championship baseball teams were definitely superior in social adjustment to boys of comparable age who did not play

Little League baseball. In this latter study, the boys who competed on the championship team were on the average approximately 5 inches taller and 33 pounds heavier than the nonparticipants.

Powers (7) studied the mental health, physical well-being, and social acceptance of boys in grades four to six who engaged in intramural and interscholastic athletic competition. In relation to the physical well-being of the subjects, he concluded that the physical well-being of interschool athletes was not different from that of intramural athletes and that the rate of progress of intramural athletes in acquiring motor skills was equal to that of interschool athletes.

In a study of boys 12 years of age, who had participated in good and poor physical education programs for a period of three years, Whittle (12) concluded that the boys who had participated in a good physical education program were superior to those who had not on the following tests: leg lift strength, Physical Fitness Index, Metheny-Johnson Test of Motor Educability, Strength Index, back lift strength, Indiana Physical Fitness Test, vertical jump, and arm strength. The boys from both the good and the poor programs who participated extensively in physical activities outside physical education classes demonstrated pronounced superiority on the same tests to those whose participation in outside activities was limited.

Procedures

Subjects. The subjects were boys in the upper elementary and junior high schools of Medford, Oregon, during the 1956-57 academic year; each boy was tested within two months of his birthday. Only those boys who were eligible for participation on elementary or junior high school interschool athletic teams were included. Thus, it was necessary to determine which of the boys tested in the over-all Medford study were in elementary or junior high school. All 11-year-old boys were in an elementary school; all 13- and 14-year-old boys were in a junior high school. However, boys 12 years of age were found in both elementary and junior high schools; likewise, 15-year-old boys were found in both junior and senior high schools. Fourth grade boys were not permitted to compete on interschool teams in Medford; because of this regulation, only those ten-year-old boys who were in the fifth grade were included.

Athletic Ratings. The subjects throughout the school year could have participated in the following interscholastic sports:

1. Upper elementary school, 5th and 6th grades: tackle football, basketball, baseball, and track and field.
2. Junior high school, 7th and 8th grades: tackle football, basketball, wrestling, and track and field.
3. Junior high school, 9th grade: same as for 7th and 8th grades, plus tennis and golf.

The coaches of the various athletic teams rated the subjects on their athletic performance for the 1956-57 school year only. They were instructed not to allow past performances or future potentialities to enter into their evaluations. The following rating system was used:

3—Exceptional athletic ability; outstanding performer.
2—Good, average player; made first team, played regularly.
1—Out for sport, but did not make first team or play regularly.
NP—Leave blank space for those boys who did not complete a full season, and for those who did not try out for teams; nonparticipants.

Many of the boys participated in more than one sport; consequently, they received more than one athletic rating. In these instances, a boy's ratings were not always the same for different sports. When this occurred, the boy was given the highest rating for purposes of this study. The following tabulations show the groupings by age and athletic ratings for all subjects.

Upper Elementary School

Age	3 Rating	2 Rating	1 Rating	NP	Total
10	2	5	2	9	18
11	3	8	14	15	40
12	9	6	5	10	30
Total	14	19	21	34	88

Junior High School

Age	3 Rating	2 Rating	1 Rating	NP	Total
12			1	9	10
13		10	6	21	37
14	8	8	8	16	40
15	5	7	4	11	27
Total	13	25	19	57	114

A total of 88 boys served as subjects for the elementary school part of the study. Of this number, 34, or 39 percent, were nonparticipants. Fourteen boys received 3 ratings; most of these (64 percent) were in the oldest age level of 12 years. Approximately an equal number of boys receive ratings of 1 and 2.

Of the 114 boys in the junior high school groups, 57, or 50 percent, were nonparticipants. Thirteen boys were given 3 ratings by the coaches; all of these were in the upper two years. Eight, or 20 percent, of the 14-year-old boys were rated as outstanding performers.

Test items. The following maturity, structural, strength, and motor measures were administered to the 202 boys included in this study:

1. Maturity measures—skeletal age and relative maturity (skeletal age as related to chronological age).

2. Structural measures—body weight; standing and sitting heights; McCloy's Classification Index I; Wetzel physique channel; chest, upper-arm, and calf girths; lung capacity.

3. Body build—five somatotype categories of endomorphs, mesomorphs, ectomorphs, endo-mesomorphs, and mid-types.

4. Muscular strength measures—Rogers' Strength Index and Physical Fitness Index; Rogers' and McCloy's arm strength scores; cable-tension strength test average (twelve tests); upper and lower body strengths (average of three cable-tension strength tests each).

5. Explosive muscular power—standing broad jump.

Analysis of Data

The basic statistical process used in analyzing the data of this study was to compute the differences between the mean scores on the various tests for boys in the three athletic classifications and the nonparticipants. This was done separately for the elementary and the junior high school groups. These differences were tested for significance at the .05 and .01 levels by application of the t ratio. The test of significance was for the difference between uncorrelated groups, since the means of independent samples were being compared. Significant t ratios for the various comparisons ranged from 1.99 to 2.04 at the .05 level and from 2.64 to 2.75 at the .01 level (3).

Results

MATURITY MEASURES

A summary o fthe differences between the maturational measure means of the nonparticipants and the three athletic groups, expressed as t ratios, appears in Table 1.

Skeletal age. Considerable similarity was found between the skeletal age t ratios of the upper elementary and junior high school boys. The highest

TABLE 1.—SUMMARY OF THE DIFFERENCES BETWEEN MEANS OF MATURATIONAL MEASURES EXPRESSED AS t RATIOS FOR THE NONPARTICIPANTS AND ATHLETIC GROUPS IN ELEMENTARY AND JUNIOR HIGH SCHOOLS

Athletic Ratings	Skeletal Age		Relative Maturity	
	Elem. Schl.	Jr. H. S.	Elem. Schl.	Jr. H. S.
NP vs 1	1.35	1.36	1.08	.92
NP vs 2	1.10	1.68	1.28	.88
NP vs 3	3.86	5.60	3.44	1.42
1 vs 2	.02	.33	.29	.09
1 vs 3	2.60	2.55	2.47	.68
2 vs 3	2.20	2.00	2.05	.54

skeletal age means were found for the members of the athletic groups; the group with the highest athletic rating in each of these comparisons also had the highest mean skeletal age. These results could have been expected since more of the older boys, chronologically, won positions on the athletic teams and achieved the highest athletic ratings. Thus, the older boys would normally be more mature as measured by skeletal age. The differences between the skeletal age means, however, were only significant when the outstanding athletes were compared with the other groups. These t ratios ranged from 2.20 to 3.86 for the elementary school boys and from 2.00 to 5.60 for the junior high school boys.

Relative maturity. Relative maturity (skeletal age as related to chronological age) was a definite factor in the athletic success of the elementary school boys, but was not significant for the junior high school boys. Among the elementary school boys, the outstanding athletes were more mature for

their age than were the nonparticipants and the boys with the lower athletic ratings. The t ratios ranged from 2.05 to 3.44. These relative maturity mean differences were the only ones which were significant at either school level.

STRUCTURAL MEASURES

Summaries of the differences between structural measure means of the nonparticipants and the three athletic groups, expressed as t ratios, appear in Table 2 for the upper elementary school boys and in Table 3 for junior high school boys. In all instances of significant differences, the advanced athletic group had the highest mean.

Body weight. For the elementary school boys, a significant difference was found only between the means of outstanding athletes and the nonparticipants; the t ratio for this difference was 2.21, which was significant at the .05 level. For the junior high school boys, however, significant t ratios were obtained when boys with athletic ratings of 3 were compared with boys with all other ratings; the t ratios ranged from 2.03 to 3.75.

Standing height. At the upper elementary school level, the 3-rated and 2-rated boys had significantly higher standing height means than the nonparticipants; the t's were 3.27 and 2.64 respectively. For junior high school boys, significant differences between means were obtained when the outstanding athletes were compared with all other groups; the t ratios ranged from 2.72 to 4.53, significant at the .01 level and beyond.

Sitting height. The distribution of the sitting height t ratios was somewhat similar to the distribution for standing height. The major difference was the presence of consistently larger t ratios when the outstanding athletes were compared with the other junior high school boys.

Classification Index I. The pattern of Classification Index I t ratios was somewhat similar to that of sitting height for the upper elementary and junior high school boys. At both school levels, the highest t ratios were obtained when the outstanding athletes were compared with the other groups. However, for the elementary school boys, the only significant difference was obtained when the outstanding athletes and nonparticipants were compared.

Wetzel Physique Channel. None of the differences between the means of the elementary and junior high school athletic and nonparticipant groups was significant, since the t ratios ranged from .06 to 1.49.

Chest girth. Chest girth was not a significant measure in differentiating between nonparticipant and athletic groups at the elementary school level. For junior high school boys, significant t ratios were obtained when the outstanding athletes were compared with the other groups; the t ratios were 1.93, 2.47, and 3.51.

Upper arm girth. The differences between the upper arm girth means of the different groups followed the same pattern found for chest girth.

Calf girth. As was true for the other girth measurements, the differences

TABLE 2.—SUMMARY OF THE DIFFERENCES BETWEEN MEANS OF STRUCTURAL MEASURES EXPRESSED AS t RATIOS FOR THE NONPARTICIPANTS AND ATHLETIC GROUPS IN THE UPPER ELEMENTARY SCHOOL

Ratings	Body Weight	Stand. Height	Sit. Height	Classif. Index I	Wetzel Physique Channel	Chest Girth	Upper Arm Girth	Calf Girth	Lung Capacity
NP vs 1	1.54	1.81	.84	1.31	.35	.88	1.21	.81	1.83
NP vs 2	.64	2.64	1.35	1.21	1.31	.35	.86	.14	2.68
NP vs 3	2.21	3.27	2.09	2.72	.61	1.48	1.59	1.83	1.96
1 vs 2	.90	.76	1.08	.13	1.49	.59	.31	.65	.73
1 vs 3	.93	1.95	2.13	1.68	.87	.68	.46	1.09	.99
2 vs 3	1.68	1.41	1.41	1.43	.45	1.24	.73	1.67	.57

TABLE 3.—SUMMARY OF THE DIFFERENCES BETWEEN MEANS OF STRUCTURAL MEASURES EXPRESSED AS t RATIOS FOR THE NONPARTICIPANTS AND ATHLETIC GROUPS IN THE JUNIOR HIGH SCHOOL

Ratings	Body Weight	Stand. Height	Sit. Height	Classif. Index I	Wetzel Physique Channel	Chest Girth	Upper Arm Girth	Calf Girth	Lung Capacity
NP vs 1	.52	.73	1.17	1.10	.77	.72	.51	.62	1.05
NP vs 2	1.28	1.24	1.86	1.24	.18	1.41	1.30	2.69	2.39
NP vs 3	3.75	4.53	5.20	5.11	.07	3.51	3.40	3.29	5.22
1 vs 2	.57	.23	.35	.02	.79	.57	.54	1.68	.44
1 vs 3	2.53	2.72	2.58	2.74	.55	2.47	2.20	2.29	2.54
2 vs 3	2.03	2.91	2.52	2.97	.06	1.93	1.85	.69	2.80

between the calf girth means of the upper elementary school nonparticipant and athletic groups were not significant. Three significant t ratios were obtained for the differences between means at the junior high school level; these were 3.29 between the 3's and nonparticipants, 2.69 between the regular players and nonparticipants, and 2.29 between the outstanding players and substitutes.

Lung capacity. At the upper elementary school level, t ratios were significant or nearly so at the .05 level for the differences between the lung capacity means of each of the three athletic groups and the nonparticipants; these t's were 1.83, 1.96, and 2.68. The t ratio pattern at the junior high school level revealed significant differences between means when the outstanding athletic group was compared with the others; the t's ranged from 2.54 to 5.22. For the junior high school boys, also, the comparison of the differences between the means of the regular players and the nonparticipants resulted in a t ratio of 2.39, significant between the .05 and .01 levels.

SOMATOTYPES

Five somatotype categories, as proposed by Irving (5), were used in this study as the basis for classifying the subjects. These categories were endomorphs, mesomorphs, ectomorphs, endo-mesomorphs, and mid-types.

At the upper elementary school level, 35.7 percent of the outstanding athletes had somatotypes in the mid-type category and 28.5 percent each were mesomorphs and ectomorphs. No endomorph and very few endo-mesomorphs were found in this athletic group. Only small differences in somatotype distributions were found between the boys with 3 and 2 athletic ratings. The nonparticipant boys resembled the total group in somatotype characteristics with the general exception that there were fewer mid-types and more of those who possessed a dominant endomorphic component.

In general, the somatotype distribution of the junior high school boys differed from the elementary school boys in the following respects: greater percentages of mesomorphs were found among all three groups of athletes (26.1 for 1's, 16.0 for 2's, and 38.4 for 3's); a much greater percentage of mid-types (40.3) was evident among the nonparticipants and a much smaller percentage from this category (23.0) was present among the 3-rated group; a greater percentage of endo-mesomorphs was found among the outstanding athletes (15.3) and regular players (16.0) and a smaller percentage from this category were found among the nonparticipants (8.7).

MUSCULAR STRENGTH MEASURES

Summaries of the differences between strength test means of the nonparticipants and the three athletic groups, expressed as t ratios, appear in Table 4 for the elementary school boys and in Table 5 for the junior high school boys. In all instances of significant differences, the advanced athletic group had the highest mean.

TABLE 4.—SUMMARY OF THE DIFFERENCES BETWEEN MEANS OF MUSCULAR STRENGTH MEASURES EXPRESSED AS t RATIOS FOR THE NONPARTICIPANTS AND ATHLETIC GROUPS IN THE UPPER ELEMENTARY SCHOOL

Ratings	Rogers' Strength Index	Physical Fitness Index	Rogers' Arm Strength	McCloy's Arm Strength	Cable-Tension Strength Average	Upper Body Strength	Lower Body Strength
NP vs 1	1.50	.79	.80	1.59	1.77	3.15	.80
NP vs 2	2.29	2.05	2.94	2.65	2.94	3.26	2.83
NP vs 3	4.06	2.48	2.92	3.53	3.47	2.56	2.40
1 vs 2	.81	1.10	1.63	.98	1.70	.09	2.19
1 vs 3	2.78	1.44	2.17	2.31	2.59	.49	1.99
2 vs 3	2.05	.32	1.12	1.60	1.26	.43	.55

TABLE 5.—SUMMARY OF THE DIFFERENCES BETWEEN MEANS OF MUSCULAR STRENGTH MEASURES EXPRESSED AS t RATIOS FOR THE NONPARTICIPANTS AND ATHLETIC GROUPS IN THE JUNIOR HIGH SCHOOL

Ratings	Rogers' Strength Index	Physical Fitness Index	Rogers' Arm Strength	McCloy's Arm Strength	Cable-Tension Strength Average	Upper Body Strength	Lower Body Strength
NP vs 1	1.95	1.59	1.95	1.25	1.77	1.68	1.50
NP vs 2	3.03	2.25	1.73	2.18	2.59	3.15	3.84
NP vs 3	5.33	2.37	5.30	5.69	5.34	4.09	4.66
1 vs 2	.70	.57	.28	.56	.64	.51	1.86
1 vs 3	3.24	1.19	2.66	3.18	3.33	2.01	2.89
2 vs 3	2.77	.77	3.05	2.88	2.79	1.84	1.25

Strength Index. The distributions of the Strength Index t ratios for the upper elementary and junior high school levels were somewhat similar; the major difference was the presence of consistently higher t ratios for the junior high school boys. The significant differences between the means were obtained when the boys with athletic ratings of 2 and 3 were compared with those in the other groups. Only three of the twelve t ratios for the difference between the means at both levels failed to reach or nearly reach the .05 level of significance. Two of these low t's, .81 and .70, represented the differences between the means of the substitutes and regular players at both the elementary and junior high school levels; the third low t ratio of 1.50 was obtained between the upper elementary school substitutes and nonparticipants.

Physical Fitness Index. At both the upper elementary and junior high school levels, significant t ratios were obtained when the Physical Fitness Index means of the outstanding athletes and regular players were compared with the means of the nonparticipants. At both levels, the t's were significant between the .05 and .01 levels.

Roger's arm strength score. At the upper elementary school level, the highest t ratios, 2.94 and 2.92, were obtained from the differences between Rogers' arm strength means of the outstanding athletes and regular players and the mean of the nonparticipants; the difference between the means of the outstanding athletes and substitutes was significant at the .05 level, since the t ratio was 2.17. At the junior high school level, significant differences between means were obtained when the outstanding athletes were compared with the other groups; the t ratios ranged from 2.66 to 5.30, significant at and beyond the .01 level. The t ratio of 1.95 for the difference between the means of the regular players and the nonparticipants nearly reached significance at the .05 level.

McCloy's arm strength score. For the elementary school boys, the differences between the means of McCloy's arm strength scores were similar to the results obtained with Rogers' arm strength scores. Thus, means of the outstanding athletes and the regular players were significantly higher than the mean of the nonparticipants. The mean of the outstanding athletes was also significantly higher than the mean of the substitutes. The same significant differences were also obtained at the junior high school level. In addition, the mean of the outstanding athletes was significantly higher than the mean of the regular players.

Cable-tension strength average. Again, the differences between the means for the cable-tension strength averages were similar to the results obtained with both Rogers' and McCloy's arm strength means. At the elementary school level, the means of the outstanding athletes and the regular players were significantly higher than the mean of the nonparticipants. The outstanding athletes had a significantly higher mean than did the substitutes. The same significant differences were obtained for the junior high school boys. Further, the mean of the outstanding athletes exceeded the mean of the regular players.

Upper-body strength. For upper-body strength, based on the average of three cable-tension strength tests (elbow flexion, shoulder flexion, and shoulder inward rotation), the mean of the nonparticipants was significantly lower than the means of the three athletic groups at the elementary school level. These differences were significant near or at the .01 level, since the t ratios ranged from 2.56 to 3.15. For the junior high school boys, the means of the outstanding athletes and regular players exceeded the mean of the nonparticipants beyond the .01 level of significance. The mean of the outstanding athletes was also significantly higher than the mean of the substitutes.

Lower-body strength. At both the elementary and junior high school levels, the means of the outstanding athletes and the regular players were significantly higher, or nearly so, than the means of the nonparticipants and substitutes on the average of three lower-body cable-tension strength tests (trunk flexion, trunk extension, and ankle dorsal flexion). The t ratios ranged from 1.99 to 2.83 for the elementary school boys and from 1.86 to 4.66 for junior high school boys.

Standing Broad Jump. A summary of the differences between the means on the standing broad jump for both the elementary and junior high school boys, expressed as t ratios, appears in Table 6. At the elementary school level, all differences between the means were significant, except when the regular players were compared with the outstanding athletes and the substitutes; the t ratios ranged from 2.52 to 4.70. At the junior high school level, the means of the outstanding athletes and regular players were significantly higher than the means of the substitutes and nonparticipants.

TABLE 6.—SUMMARY OF THE DIFFERENCES BETWEEN MEANS OF STANDING BROAD JUMP EXPRESSED AS t RATIOS FOR THE NONPARTICIPANT AND ATHLETIC GROUPS AT BOTH SCHOOL LEVELS

Ratings	t-Ratios	
	Upper Elementary	Junior High
NP vs 1	2.52	1.54
NP vs 2	4.70	2.53
NP vs 3	4.50	6.66
1 vs 2	1.77	.78
1 vs 3	2.60	4.61
2 vs 3	1.48	4.01

Summary

Most earlier studies in the area of this investigation attempted to determine effects of athletics on boys. Certain of these studies found that nonathletes surpassed athletes on such anthropometric tests as weight, height, and lung capacity. However, other studies have shown that boys who were successful in making interschool athletic teams were physiologically more mature than nonparticipants. The fact that the growth of mature boys had thereby been accelerated could logically account for the lack of rapid additional growth

of the athletes. In terms of strength tests, motor fitness tests, and motor ability measures, one study (12) clearly demonstrated that elementary school boys who participated in good physical education programs and who participated a lot in out-of-school physical activities had generally much higher scores that those who engaged in poor physical education programs and little in out-of-school physical activities.

The results of the present study are not in essential variance with those of earlier investigations. However, many more variables were included in this study and these were applied more extensively. The following summary of results is presented.

1. The outstanding athletes in both upper elementary and junior high schools had significantly higher mean skeletal ages than did the nonparticipants, substitutes, and regular players. This result could well be due to the fact that older boys usually make athletic teams. However, in studying the relative maturity of the subjects, the outstanding elementary school athletes only were found to be physiologically advanced.

2. In general, the size of athletes as compared with nonparticipants was more significant at the junior high school than at the elementary school level; this was particularly true for the outstanding athletes. The most significant anthropometric measures in differentiating between nonparticipants and the athletic groups at both school levels were body weight, height, and lung capacity. At the junior high school level, arm girth, chest girth, and calf girth were also important differentiators.

3. The body physiques of the subjects, as shown by their somatotypes, generally followed the same pattern as for the anthropometric tests. The somatotype distribution of junior high school boys differed from the elementary school boys in the following respects: a greater percentage of mesomorphs was found among all three groups of athletes; a much greater percentage of mid-types was present among the nonparticipants and a much smaller percentage from this category was found among the 3-rated group; a greater percentage of endo-mesomorphs was evident among the outstanding athletes and regular players.

4. Strength was a consistent differentiator of athletic ability. At both school levels, the Strength Index means of the outstanding athletes were significantly higher than the means of the other groups. For the junior high boys, a similar superiority was found in Rogers' and McCloy's arm strength scores and in cable-tension strength test average. The Strength Index mean of the nonparticipants was significantly below the means of all athletic groups at the junior high school level. For both the upper elementary and junior high school boys, the Physical Fitness Index means of the outstanding athletes and regular players were significantly higher than were the means of the nonparticipants.

In addition to the above, the outstanding athletes showed superiority over the nonparticipants and substitutes as follows: lower body cable-tension strength at both school levels, Rogers' and McCloy's arm strength scores and

cable-tension strength test average for elementary school boys, and upper body strength for junior high school boys. Also, the regular players had significantly higher means than the nonparticipants as follows: McCloy's arm strength score, cable-tension strength test average, and lower body strength at both school levels; Strength Index and Rogers' arm strength score for elementary school boys; upper body strength for junior high school boys.

5. In the standing broad jump, the means of the outstanding athletes and the regular players were significantly higher than the means of the nonparticipants at both school levels. The outstanding athletes were also superior to the substitutes on this test. For the elementary school boys, the substitutes had a higher jump mean than did the nonparticipants; for the junior high school boys, the outstanding athletes demonstrated superiority over the regular players. In these comparisons, the standing broad jump produced the highest t ratios of the entire study.

Conclusions

This study did not attempt to determine the effects of participation on interschool athletic teams upon the boys, as the subjects were tested once only. Effects can only be found when tests are administered over a period of time, during which the subjects participated on athletic teams with proper nonparticipant controls established as a basis of reference. Furthermore, this study did not provide an evaluation of psychological, social, and emotional factors usually considered as significant in athletic situations.

This study, however, does demonstrate that boys who make and are successful on interschool athletic teams at both elementary and junior high school levels are definitely superior in maturity, body size and build, both absolute and relative (to weight and age) muscular strength, and explosive muscular power. Thus, the decision as to whether boys are physically ready for such participation should be determined on factors other than chronological age (or grade in school), as is commonly done today. Actually, within age limitations, natural selection takes place, based in part at least on those factors included in this study.

References

1. DeLotto, Marcel, "The Effects of Competitive Athletics on the Growth and Development of Pre-Pubescent Boys." Doctoral dissertation. University of Oregon, 1954.
2. Fait, Hollis. "An Analytical Study of the Effects of Competitive Athletics upon Junior High School Boys." Microcarded Doctoral dissertation. State University of Iowa, 1951.
3. Garrett, Henry E. *Statistics in Psychology and Education*, 5th Edition. New York: Longmans, Green and Co., 1958.
4. Hale, Creighton J., "Physiological Maturity of Little League Baseball Players." *Research Quarterly* 27: 276-84; October 1956.
5. Irving, Robert N. "Comparison of Maturity, Structural, and Muscular Strength Measures for Five Somatotype Categories of Boys Nine Through Fifteen Years of Age." Microcarded Doctoral dissertation. University of Oregon, 1959.
6. Krogman, Wilton M. "Factors of Physical Growth of Children as They May Apply

to Physical Education." *American Association for Health, Physical Education, and Recreation Proceedings* 60, 1954.

7. POWERS, EUGENE P. "A Study of the Effects of Interschool Athletics on the Physical Well-Being, Mental Health, and Social Acceptance of Boys in Grades Four, Five, and Six." Doctoral dissertation. Temple University, 1955.
8. ROWE, FLOYD A. "Growth Comparison of Athletes and Non-Athletes." *Research Quarterly* 4: 108; 1933.
9. SALZ, ARTHUR E. "Comparison Study of Personality of Little League Champions, Other Players in Little League, and Non-Playing Peers." Microcarded Master's thesis. Pennsylvania State University, 1957.
10. SEYMOUR, EMERY W. "A Comparative Study of Certain Behavior Characteristics of Participant and Non-Participant Boys in Little League Baseball." Microcarded Doctoral dissertation, Springfield College, 1955.
11. SKUBIC, ELVERA. "An Experimental Investigation of the Emotional Responses of Boys to Little League and Middle League Competitive Baseball." Microcarded Doctoral dissertation. University of Southern California, 1954.
12. WHITTLE, H. DOUGLAS. "Effects of Elementary School Physical Education upon Some Aspects of Physical, Motor, and Personality Development of Boys Twelve Years of Age." Microcarded Doctoral dissertation, University of Oregon, 1956.

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Prevention of Muscular Distress after Exercise

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Abstract

A four-minute standard exercise consisting of wrist hyperextension every two seconds with 9½ pounds of resistance was administered to 17 subjects. The subjects then applied static stretching technique to the nondominant arm immediately after the exercise and 2, 6, 20, and 22 hours afterward. Observations of muscular distress were made on both arms during the exercise and at 4, 8, 24, 48, and 72 hours after the exercise.

Significantly lesser magnitudes of muscular distress were found in the experimental arm at the 24- and 48-hour observations, at the .01 and .05 levels of confidence respectively. A lower level of muscular distress was also found in the experimental arm when all observations for each subject subsequent to the exercise bout were summed. This difference achieved significance at the .01 level of confidnce.

THE CAUSE OF muscular soreness which occurs after unaccustomed exercise seems to be poorly understood. In general, two types of muscle soreness have been postulated since the early work by Hough (7): (a) an early and general soreness occurring usually within 4 to 8 hours and which disappears rapidly, and (b) a localized soreness or lameness, also called a myositis by some, which usually appears 2 to 24 hours after exercise and which may persist for several days. The first type is held to be due to the presence of diffusible metabolites (3, 7, 9, 10, 14, 17), and the second type is widely believed to be the result of tissue damage (3, 4, 5, 7, 9, 10, 14, 16, 17) such as torn muscle fibers and/or torn connective tissues.

However there are some dissenting opinions to be found in the literature. Boyle (2) in an unpublished study could find no correlation between increase in volume of an exercised arm and presence of soreness. He also finds Hough's theory of pain due to tearing of muscle fibers hard to believe, since there is no mention of pain at the time of tearing. Karpovich (8) stated it thus: "Hough explained the soreness by supposing that a number of muscle fibers become ruptured. There is no doubt that violent exercise may cause extensive muscle rupture, but the term 'violent' can hardly be applied to most activities which result in muscle soreness. Since no experimental evidence has been presented to substantiate Hough's theory, the author of this book does not subscribe to this theory." Karpovich goes on to suggest that Hough's theory of soreness may be merely a plausible explanation and that further search be made for a better one.

Many of the opinions in the literature regarding causation of muscular soreness seem to be based upon the work done by Hough (6,7) in the last

years of the nineteenth century. There seems to have been no experimental evidence presented since then to substantiate this theory of muscular soreness due to tissue damage.

Therefore, this study was conducted to test a new working hypothesis concerning the cause of muscle soreness and to test simultaneously a method for its relief and/or prevention. This hypothesis may be stated thus: Muscular distress following unaccustomed exercise is caused at least in part by tonic muscle spasm. As a corollary to this hypothesis, it could be stated also: If muscular distress following unaccustomed exercise is caused in any way by tonic muscle spasm, then some degree of prevention should be brought about through the use of a static stretch, similar in principle to that used commonly by swimmers to relieve cramp in the calf muscles. The method alluded to is that of leaning forward in the standing position with the hands placed against a wall while keeping the feet parallel and heels flat upon the floor in order to gently but forcibly place the cramped calf muscles on stretch.

Throughout the remainder of this study the term muscular distress is used to include all symptoms of muscular pain, stiffness, or soreness, since these terms are difficult to differentiate and do not seem to enjoy any large degree of standardization of usage in the literature.

Procedures

SUBJECTS

The subjects were 17 volunteers from the investigator's professional class in corrective physical education at Long Beach State College. Two were women and 15 were men. All subjects were of the Caucasian race and their age ranged from 20 to 29 years.

EXPERIMENTAL DESIGN

After several pilot studies, a standard exercise was selected to produce muscular distress. This standard exercise was of four minutes duration. It consisted of wrist hyperextension with the subjects seated upon the floor with legs outstretched underneath a bench 17 inches in height; the forearms rested comfortably upon the bench with hands and wrists extending far enough beyond the far edge of the bench so that there was no interference with full wrist flexion or hyperextension. Each subject used a dumbbell weighing 9½ pounds made up so that the 5-pound weight was in the middle of the bar and both hands could grasp the dumbbell bar comfortably in pronated position outside the collars holding the 5-pound weight in place. Each subject had a partner who held the subject's forearms down to the bench at the elbow joint to prevent possible muscle substitution. A cadence of 30 wrist hyperextensions per minute was counted off with the aid of a metronome set at 120 counts per minute. Each wrist hyperextension was done to a four-count—"up-two-three-four"—and the subjects were instructed to attempt full wrist hyperextension on "up" with return to the starting posi-

TABLE 1.—RATINGS OF MUSCULAR DISTRESS AS A RESULT OF STANDARD EXERCISE

Subject	Duration of Exercise	During Ex.		4 Hrs.		8 Hrs.		24 Hrs.		48 Hrs.		72 Hrs.	
		Exp. arm	Cont. arm	Exp. arm	Cont. arm	Exp. arm	Cont. arm	Exp. arm	Cont. arm	Exp. arm	Cont. arm	Exp. arm	Cont. arm
1	4 min. 0 sec.	3	3	0	0	1	1	2	2	0	1	0	1
2	4 min. 0 sec.	2	1	0	0	0	0	0	0	0	0	0	0
3	4 min. 0 sec.	1	1	0	0	0	0	0	0	0	0	0	0
4	3 min. 0 sec.	1	1	0	0	0	0	0	0	0	0	0	0
5	4 min. 0 sec.	2	2	2	3	1	3	1	2	1	2	0	0
6	4 min. 0 sec.	1	1	0	1	0	0	1	0	0	0	0	0
7	4 min. 0 sec.	2	2	0	1	0	1	0	0	0	0	0	0
8	4 min. 0 sec.	1	1	0	0	0	0	0	0	0	0	0	0
9	4 min. 0 sec.	3	3	2	2	0	1	0	0	0	0	0	0
10	4 min. 0 sec.	2	2	0	0	0	0	0	0	0	0	0	0
11	2 min. 30 sec.	0	0	0	0	0	0	0	0	0	0	0	0
12	4 min. 0 sec.	2	2	0	0	0	0	0	0	0	0	0	0
13	2 min. 15 sec.	3	3	2	2	1	1	1	1	0	1	0	0
14	4 min. 0 sec.	3	3	0	0	0	0	1	1	0	1	0	0
15	4 min. 0 sec.	3	3	0	1	0	1	1	2	1	2	1	1
16	4 min. 0 sec.	2	2	0	0	0	0	1	2	1	1	0	0
17	4 min. 0 sec.	2	2	0	0	0	0	1	2	0	1	0	0
		Sign[a]	Sign[a]	Sign[a]	Sign[a]	Sign[a]	Sign[a]	Sign[a]	Sign[a]	Sign[a]	Sign[a]	Sign[a]	Sign[a]
1	4 min. 0 sec.	0	0	0	0	0	0	0	0	0	0	0	0
2	4 min. 0 sec.	0	+	0	0	0	0	0	0	0	0	0	0
3	4 min. 0 sec.	0	0	0	0	0	0	0	0	0	0	0	0
4	3 min. 0 sec.	0	0	0	0	0	0	0	0	0	0	0	0
5	4 min. 0 sec.	0	0	0	0	0	0	0	0	0	0	0	0
6	4 min. 0 sec.	0	0	0	0	0	0	0	0	0	0	0	0
7	4 min. 0 sec.	0	0	0	0	0	0	0	0	0	0	0	0
8	4 min. 0 sec.	0	0	0	0	0	0	0	0	0	0	0	0
9	4 min. 0 sec.	0	0	0	0	0	0	0	0	0	0	0	0
10	4 min. 0 sec.	0	0	0	0	0	0	0	0	0	0	0	0
11	2 min. 30 sec.	0	0	0	0	0	0	0	0	0	0	0	0
12	4 min. 0 sec.	0	0	0	0	0	0	0	0	0	0	0	0
13	2 min. 15 sec.	0	0	0	0	0	0	0	0	0	0	0	0
14	4 min. 0 sec.	0	0	0	0	0	0	0	0	0	0	0	0
15	4 min. 0 sec.	0	0	+	+	+	+	0	0	0	0	0	0
16	4 min. 0 sec.	0	0	0	0	0	0	0	0	0	0	0	0
17	4 min. 0 sec.	0	0	0	0	0	0	0	0	0	0	0	0

[a] Sign is negative when muscular distress in experimental arm is less than that in control arm and positive when muscular distress in experimental arm is greater than that in control arm (12:68).

tion of wrist flexion on two and rest on counts three and four. This count was used because Hough found that a rhythm consisting of a contraction phase of .5 seconds with a relaxation phase of 1.5 seconds produced considerably more muscle soreness than other combinations in his experiments.

All but three subjects were able to complete the standard exercise. Immediately following the standard exercise, the subjects stretched the wrist flexors and then the extensors of the nondominant arm. This was accomplished by a static stretch of 1-minute duration in each case. The static stretching of the wrist flexors was done by having the subject stand slightly more than arm's distance from and facing a wall, then placing the hand flat on the wall with the middle finger pointing upward, resting the weight against this hand with the arm extended and maintaining the hand as far downward on the wall as possible. The static stretching of the wrist extensors was done immediately following and in the same fashion but with the back of the hand resting against the wall and as high up the wall as possible with the middle finger pointing downward.

This static stretching procedure was used in preference to a rebounding type of stretching for two reasons. First, this static type of stretching has been widely used to relieve muscle cramp in swimmers, and secondly, static stretching would not confound the results of stretching with the results of circulatory effects as might have occurred with a rebounding type stretching program. The nondominant arm was used as the experimental arm because it might be thought to be the poorer conditioned if any difference existed and thus might be thought more likely to develop symptoms of distress.

The subjects were provided with the form shown in Figure I and were instructed to repeat the stretching procedure on the nondominant arm only at 2, 6, 20, and 22 hours following the standard exercise which was administered at noon to permit this procedure. It is the investigator's opinion that all subjects cooperated to the best of their ability as it appeared that there was considerable interest in the experiment. The subjects were told only that the experiment was to test the effects of a static stretching program upon subsequent muscle distress.

Treatment of the Data

The results of the experiment are set forth in Table 1. During the standard exercise, 16 of the 17 subjects observed some degree of muscular distress, and of these 16 subjects, 15 reported the same degree of distress in both arms. In the observation made at four hours following the standard exercise only six subjects observed any symptoms; one finding moderate distress in both arms, one finding greater distress in the stretched or experimental arm, and the remaining four finding less distress in the experimental arm. At the eight hour observation, eight subjects found symptoms of muscular distress, two of whom reported mild symptoms in both arms while one reported less distress in the control arm and five observed less distress in the experimental arm. At the 24-hour observation,

Group.....

Class.....

MUSCLE SORENESS EXPERIMENT

Name..... Date.....

Exercise..... Sex..... Age.....

Duration..... Cadence.....

Muscles.....

.....

.....

Remedial Measures .....

Magnitude of Muscular Distress

	Left Side				Right Side			
	3 SEVERE	2 MODERATE	1 MILD	0 NONE	3 SEVERE	2 MODERATE	1 MILD	0 NONE
During Test								
4 hrs. after								
8 hrs. after								
24 hrs. after								
48 hrs. after								
72 hrs. after								

DEFINITIONS FOR THE GRADATION OF MUSCLE DISTRESS

0. NONE — No noticeable effects or symptoms
1. MILD — Barely perceptible symptoms of pain, soreness, or stiffness, which are apparent only upon palpation (pressure of fingers)
2. MODERATE — Symptoms of pain, soreness, or stiffness which interfere with normal muscular function to a slight degree (noticed upon flexion or extension)
3. SEVERE — Symptoms of pain, soreness, or stiffness which interfere with normal muscular function to a marked degree.

FIGURE I.

9 of the 17 subjects detected symptoms of muscle distress. One subject found moderate symptoms in both arms, one subject found mild symptoms in both arms, and seven subjects reported less muscular distress in the experimental arm. The 48-hour observation showed eight subjects reporting distress, three of whom observed the same degree in both arms and five of whom observed lesser symptoms in the experimental arm.

By the time the final 72-hour observation was made, all but three of the subjects who had experienced any distress symptoms had recovered, and of these three, one had mild symptoms remaining in both arms, while the other two subjects had mild symptoms only in the control arm.

To summarize the data, of the 17 subjects who participated in the experiment, 13 or 76.5 percent experienced some degree of muscular distress following the standard exercise, and this compares closely with the 85 percent reported by Hough for the same cadence used in finger flexion in his experiments. Of the 13 subjects reporting muscle distress throughout the various observation points in the experiment, one subject found greater symptoms in the experimental arm while 12 subjects observed lesser degrees of muscular distress in the experimental arm.

At this point a null hypothesis was set up and stated thus: The observed differences represent a sample from a population of differences whose mean difference is zero. The .05 level of confidence was set as the level beyond which the null hypothtsis would be rejected. To test this null hypothesis, the nonparametric sign test as recommended by Siegel (12) was employed to test the differences of the pooled data as shown in Table 2. From the pooled data it can be seen that 11 of 12 subjects reported less total muscular distress, in the experimental arm when all ratings subsequent to the standard exercise

TABLE 2.—A COMPARISON OF THE SUM OF ALL MUSCULAR DISTRESS RATINGS SUBSEQUENT TO THE STANDARD EXERCISE

Subject	Sum of Ratings		
	Experimental Arm	Control Arm	Sign[a]
1	3	5	−
2	0	0	0
3	0	0	0
4	0	2	−
5	5	10	−
6	0	1	−
7	0	2	−
8	1	2	−
9	4	6	−
10	0	0	0
11	0	0	0
12	0	1	−
13	3	0	+
14	3	3	0
15	3	6	−
16	2	5	−
17	1	3	−

[a] Sign is negative when muscular distress in experimental arm is less than that in control arm and positive when muscular distress in experimental arm is greater than that in control arm (12:68).

are summed. The probability for the occurrence of these data through chance was found to be .003 with a one-tailed test which is appropriate since the working hypothesis postulates direction. On this basis the null hypothesis was rejected, and it was concluded that factors other than chance probably operated in the experiment. Further tests were made with the sign test for each

set of observations independently and the results of these tests are given in Table 3. It was found that the differences in ratings suggesting less muscular

TABLE 3.—SIGN TEST[a] OF DIFFERENCES IN MUSCULAR DISTRESS BETWEEN EXPERIMENTAL AND CONTROL ARMS

Time of Observation	No. of Exp. Arms Observing Less Distress	Probability	Significant
During Exercise	0 of 1	----	No
4 Hrs. after Ex.	4 of 5	.188	No
8 Hrs. after Ex.	5 of 6	.109	No
24 Hrs. after Ex.	7 of 7	.108	Yes
48 Hrs. after Ex.	5 of 5	.031	Yes
72 Hrs. after Ex.	2 of 2	----	No
Sum of Observations except "During"	11 of 12	.003	Yes

[a] Sign is negative when muscular distress in experimental arm is less than that in control arm and positive when muscular distress in experimental arm is greater than that in control arm (12:68,250).

distress in the stretched or experimental arm achieved significance at the .01 and .05 levels only for the 24- and 48-hour observations respectively.

Discussion

At least since the time of Hough's early investigations into the cause of muscular soreness, it has been a rather widely accepted opinion that the late appearing and localized soreness following unaccustomed exercise bouts is due to a rupturing of muscle fibers and/or connective tissues. Karpovich has pointed out that it is unreasonable to postulate rupturing of muscle fibers in many less violent forms of exercise which are known to produce muscle soreness. In the many years since Hough presented this hypothesis there seems to have been no experimental evidence presented to support his thesis. Furthermore, it might be considered somewhat unreasonable to postulate structural damage to a tissue caused by the function for which it is specifically differentiated.

The hypothesis suggested in this study, that muscular distress following unaccustomed exercise is caused at least in part by tonic muscle spasm, is given permissive support in that the subjects in this experiment observed significantly less muscular distress in the experimental arm which was stretched than in the control arm which was not. Since muscular distress is one of the unpleasant concommitants of physical education classes and athletic activity, possible means for lessening or preventing this undesirable phenomenon should certainly bear further investigation. It would be very interesting to determine the effects of this static stretching technique upon other samples, upon other muscle groups, and under varying conditions of exercise.

Summary

A four-minute standard exercise of 30 wrist hyper-extensions per minute with a 9½ pound dumbbell was administered to 17 professional physical education students. All the subjects were of the Caucasian race and ranged from 20 to 29 years of age. Immediately following the exercise and at 2, 6, 20, and 22 hours following the exercise the wrist flexors and then the wrist extensors were stretched by static methods for one minute each, but only for the nondominant arm which became the experimental arm. The dominant arm was not stretched and was thus used as a control. Observations were made by the subjects of the degree of muscular distress in both arms and were recorded upon a prepared form for the following periods: during exercise, 4 hours, 8 hours, 24 hours, 48 hours and 72 hours following the exercise. Muscular distress was observed by the greatest number of subjects at the 24-hour observation with 9 of the 17 subjects recording some degree of distress at this point. Throughout the course of the experiment, 13 of the 17 subjects recorded some degree of muscular distress for at least one observation.

When the ratings of the experimental and control arm for each subject were compared, it was found that lesser degrees of muscular distress were recorded for the experimental arm than the control arm at every observation except the "during exercise" observation at which time only one of the 17 subjects found any difference. Of the 12 subjects who observed differences subsequent to the "during exercise" observation, 11 reported less total muscular distress in the experimental arm. When the sign test was applied to these data, the observed difference was found to be highly significant with $P = .003$. At the 24-hour observation, all of the seven subjects reporting differences between the two arms found less muscular distress in the experimental arm, and the probability for this occurrence due to chance was found to be .008. At the 48-hour observation, all of the five subjects reporting differences between the two arms found less distress in the experimental arm, and this was also a statistically significant difference at $P = .031$. Although there was less distress observed in the experimental than in the control arm at the other observation periods, no statistically significant differences were found.

Conclusions

Under the conditions and limitations of this experiment the evidence seems to permit the following conclusions:

1. Under certain conditions static stretching of both agonists and antagonists involved in unaccustomed exercise seems to result in a lessened degree of muscular distress.

2. Permissive support is provided for the hypothesis that muscular distress following unaccustomed exercise is caused at least in part by tonic muscle spasm.

References

1. Bilik, Samuel E. *The Trainers Bible.* New York: T. J. Reed and Company, 1946.
2. Boyle, Robert William. *Some Observations on the Effects of Exercise on the Blood Lymph and Muscle in its Relation to Muscle Soreness.* Unpublished doctoral dissertation. University of Minnesota, 1936.
3. Bresnahan, George Thomas, and Tuttle, W. W. *Track and Field Athletics.* St. Louis: The C. V. Mosby Company, 1950.
4. Cramer, Frank; Boughton, L. L.; and Cramer, Charles. *A Training Room Manual.* Gardner, Kansas: Cramer's, 1945.
5. Deaver, G. G. "Athletic Injuries—A Discussion of Muscles." *Journal of Health and Physical Education* 6: 28-31; February, 1935.
6. Hough, Theodore. "Ergographic Studies in Neuro Muscular Fatigue." *American Journal of Physiology* 5: 240-265; 1901.
7. Hough, Theodore. "Ergographic Studies on Muscular Soreness." *American Journal of Physiology,* 7: 76-81; 1902.
8. Karpovich, Peter V. *Physiology of Muscular Activity.* Philadelphia: W. B. Saunders Company, 1956.
9. Morehouse, Laurence E., and Miller, Augustus T. *Physiology of Exercise.* St. Louis: The C. V. Mosby Co., 1959.
10. Morehouse, Laurence, and Rasch, Philip J. *Scientific Basis of Athletic Training.* Philadelphia: W. B. Saunders Co., 1958.
11. Oldfield, Michael C. "Athlete's Hernia of the Tibialis Anticus Muscles." *British Journal of Surgery,* 36: 405; 1949.
12. Siegel, Sidney. *Non Parametric Statistics.* New York: McGraw Hill Book Company, Inc., 1956.
13. Slocomb, Charles H. "Classification of Diseases of the Muscles." Cecils *Textbook of Medicine.* Philadephia: W. B. Saunders Co., 1955.
14. Staton, Wesley M. "New Approach to Muscle Soreness." *Athletic Journal.* 31: 24; May 1951.
15. Staton, Wesley M. "Influence of Ascorbic Acid in Minimizing Post Exercise Muscle Soreness in Young Men." *Research Quarterly* 23: 356-60; October 1952.
16. Thorndyke, Augustus Jr. *Athletic Injuries.* Philadelphia: Lea & Febiger, 1948.
17. Woodward, Christopher. *Sports Injuries.* London: Max Parrish and Co., Ltd., 1954.

(Submitted 6/28/60)

Motor Performances of Adolescent Boys and Girls of Today in Comparison with Those of 24 Years Ago[1]

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Abstract

Gross motor tests were given to subjects of the California Adolescent Study in 1934-35. These same tests were given in 1958-59 to pupils of the same age and grade enrolled in the same school. Performances of boys and girls of today were superior in jump-and-reach and in the dynamometric strength "pull" test. Boys of today excelled also in throw for distance, Brace test, and grip strength. Boys and girls of 24 years ago were superior in dash and broad jump.

CURRENT INTEREST IN fitness of American youth has stimulated a number of programs of measurement of motor performances. Although there have been many such programs in the last 50 years, actual repetition of the same measures on comparable groups under similar conditions but separated by more than two decades has never been reported. It is the purpose of this study to compare performances of adolescent boys and girls of 1958-59 with those of students of the same age, grade, and school in 1934-35.

Subjects

In 1934-35, measures of motor performance were first administered to the California Adolescent Study Group (1). At that time, the latter were in the eighth grade in a junior high school in Oakland, California. In 1958-59, this same junior high school was still the only one in this particular section of the city. The school population had almost doubled in the 24-year interim. New buildings had been located on the playground, reducing considerably the area available to physical education. The jumping pit had been sacrificed due to space limitations. A small gymnasium shared by boys and girls had replaced earlier temporary structures.

The physical education program for girls was remarkably similar to that conducted earlier and the same teacher was in charge. The boys' program had required more modification due to the restricted space. Track and field

[1]This study was made possible through the generous cooperation of administrators and teachers of the Oakland Public Schools, Oakland, California.

had been eliminated entirely and outdoor activities were adapted to the limited space available.

A comparison of the present school population with the earlier one on the basis of IQ, socioeconomic status, and other characteristics was made recently by Jones (3). The neighborhoods involved in this study have to a fairly high degree remained stable. In the 1930's the economic depression was evident and affected a number of families in the sample. At present, family incomes are higher. The percentage of nonwhite children is slightly greater now. IQ averages were 105 in both periods. The two groups are remarkably similar.

In the present study, all eighth-grade boys and girls who were physically able to participate were tested. Since the early sample was entirely white, data for nonwhites in the present group were not included in the results presented.

Procedure

The senior author collected the 1934-35 data on physical abilities and supervised the 1958-59 testing. In so far as possible, identical procedures were followed. The measures included height, weight, 50-yard dash, standing broad jump, jump and reach, softball throw for distance, Brace test, and three dynamometric strength measures: grip (preferred hand), "push" and "pull" (2). The instruments used for the latter measures were the same ones used in the early study, but were recalibrated to ensure accuracy. All subjects took all tests except the Brace. Since this was given to small groups by the junior author, time did not permit testing everyone. Instead, random samples consisting of approximately one third of the total group of boys and of girls were drawn.

The 1934-35 testing was the first of its kind ever experienced by the Adolescent Group. The same was true of the 1958-59 sample. In both years, the school administrators and teachers were most cooperative and interested and the boys and girls seemed to be highly motivated.

Results and Discussion

Results are reported in Table 1 (girls) and Table 2 (boys). Boys and girls of today are taller and heavier than those of the same age, grade, and school of 24 years ago. Girls average one inch taller and six pounds heavier. Differences for boys are over two inches and ten pounds. Better nutrition and almost certainly earlier maturity must account for these differences.

Both boys and girls of today are significantly poorer than those of the earlier period in dash and broad jump but better in the jump and reach. Boys of today are superior also in throwing for distance and in the Brace test.

In dynamometric strength measures, both boys and girls of today are superior in the "pull." Present-day boys also excel in the grip. Girls of the earlier period were superior in the "push."

These findings are not readily explained. The girls of the Adolescent

TABLE 1.—COMPARISON OF RESULTS FROM TWO TEST PERIODS WITH EIGHTH GRADE GIRLS

	Fall 1934			Fall 1958			
	No.	Mean	Sigma	No.	Mean	Sigma	t
Age	93	13.0	.41	142	13.0	.43	
Height	93	61.5	2.42	142	62.4	2.52	2.88[a]
Weight	93	104.9	13.57	142	110.8	15.80	3.08[a]
Dash	78	7.8	.60	142	8.3	.62	−5.74[a]
Throw	79	70.8	15.96	142	68.7	17.31	− .92
Brd-jmp	78	66.7	7.59	142	61.5	7.93	−4.71[a]
Jmp & R	79	10.2	2.03	142	11.3	2.01	3.79[a]
Brace	73	11.3	2.97	53	12.3	3.20	1.77
Grip	93	27.7	5.20	142	27.4	4.22	− .45
Push	93	28.8	6.76	142	26.2	6.59	−2.90[a]
Pull	93	19.2	5.61	142	21.5	4.36	3.40

[a]Significant at the .01 level.

TABLE 2.—COMPARISON OF RESULTS FROM TWO TEST PERIODS WITH EIGHTH GRADE BOYS

	Spring 1935			Spring 1959			
	No.	Mean	Sigma	No.	Mean	Sigma	t
Age	94	13.5	.22	120	13.5	.44	
Height	94	62.2	3.47	120	64.4	2.89	4.86[a]
Weight	94	101.9	17.45	120	112.2	19.83	4.02[a]
Dash	80	7.3	.59	120	7.5	.56	−2.17[b]
Throw	85	115.5	20.88	120	135.9	32.10	5.89[a]
Brd jmp	81	74.8	7.62	120	70.2	8.64	−3.93[a]
Jmp & R	85	12.8	2.55	120	14.8	2.62	5.23[a]
Brace	82	13.0	2.76	45	14.8	3.08	3.16[a]
Grip	92	33.4	5.68	120	35.6	6.16	2.82[a]
Push	90	30.5	7.08	120	30.7	9.12	.20
Pull	90	25.7	6.63	120	28.7	5.46	3.54[a]

[a]Significant at the .01 level.
[b]Significant at the .05 level.

Study were retested on the same events at six months intervals for several years. The results of the present-day group on the physical ability tests (also height and weight) are remarkably like those of the Adolescent Group at 15 years of age.[2] The same does not hold true for the strength measures, however.

It was noted above that the present-day program of physical education for boys does not include track whereas the 1934-35 program did. Possibly lack of practice may explain the poor present-day performance in dash and broad jump. Superiority of today's group in most other events may be related to size since height and weight have been shown to correlate positively with performances of boys of 13.5 years.

Conclusions

In summary, it may be stated that:

1. Boys and girls of today were taller and heavier than were those of the same age, grade, and school 24 years ago.

2. Girls of today were significantly superior in jump and reach and "pull" but inferior to the earlier comparable group in dash, broad jump, and "push."

3. Boys of today were significantly superior in jump and reach, throw for distance, Brace, grip, and "pull" but inferior in dash and broad jump.

[2]The Adolescent Group scores on dash and broad jump declined with age, while those on other events increased slightly.

References

1. ESPENSCHADE, ANNA. *Motor Performance in Adolescence.* Monograph of the Society for Research in Child Development 5: No. 1; 1940.
2. JONES, HAROLD E. *Motor Performance and Growth.* Berkeley: University of California Press, 1949.
3. JONES, MARY C. "A Comparison of the Attitudes and Interests of Ninth-Grade Students over Two Decades." *Journal of Educational Psychology* 51: 175-87; August 1960.
4. MELENEY, HELEN E. *Motor Performance of Adolescent Girls Today as Compared with Those of Twenty-Four Years Ago.* Master's thesis. Berkeley: University of California, 1959.

(Submitted 8/30/60)

Comparison of Fitness of Danish and American School Children[1]

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Abstract

As a partial determination of fitness, the Youth Fitness Test of the American Association for Health, Physical Education, and Recreation was given to 319 male and 134 female Danish school children. The results of the testing were compared to the American standards, which were compiled in terms of both age and the Neilson-Cozens Classification Index. It was found that approximately 70 percent of the boys' scores and 86 percent of the scores of the girls exceeded the various American mean scores. Possible causes of these differences are discussed.

APPROXIMATELY SIX YEARS AGO the results of the Kraus-Weber Test for Muscular Fitness received a great deal of publicity and focused the attention of American physical educators, as well as the American public, on the problem of youth fitness. It was reported (4.5) that, in the battery of six tests, the incidence of failure of American children was 44.3 percent in the test of flexibility and 35.7 percent in the tests of muscular strength. When compared to the combined results of three groups of European children, the incidences of failure of the Americans were approximately 20 times as great in flexibility and five times as great in strength. While the Kraus-Weber Test and the interpretation of the investigation were subjected to a great deal of controversy, it must be admitted that the test did show that there were certain differences of one type or another between American and European children.

One of the criticisms of the Kraus-Weber Test was that it employed movements that were quite similar to those found in the activities of the gymnastically-oriented European physical education and sport programs. With the development of the AAHPER Youth Fitness Test, however, the opportunity was presented for using an American test developed and used by American physical educators. The published standards (1) also made it quite easy to compare other groups with the results of of the 8,500 American children who participated in the establishment of the norms.

In the interest of determining the relative fitness of a group of Danish school children and comparing the results with American school children, the AAHPER Youth Fitness Test was selected for administration to a representative group of school boys and girls in Denmark.

Procedure

The AAHPER Youth Fitness Test was administered to 209 boys and 134 girls at Ordrup Gymnasium and to 110 boys at Gammel Hellerup Gymnasium

[1]From Gymnastik Teoretiske Laboratorium, Juliane Maries Vej 32.

(a Gymnasium is a public school that prepares the highest 5 percent in intelligence of the junior and senior high school population for higher education in Denmark). The students came from the various classes between "2-mellem" and "III-G," which correspond to the 7th through the 12th grades in the United States. The testing program was carried out between September 1959 and May 1960. The tests were administered according to the exact directions presented in the AAHPER Test Manual. The boys and girls were tested during the course of their regular physical education program and no time was devoted to special conditioning or to the practice of the events.

The norms published in the AAHPER Test Manual are presented in terms of percentile groups of every 5 percent of the American results. These have been determined both on the basis of age and on the basis of the Neilson-Cozens Classification Index. This is to say that, if the group of Danish boys and girls was identical in fitness to the American group, 5 percent of their total number would be found in each percentile group and, therefore, 50 percent on each side of the American mean scores. For the sake of simplification in the presentation of the results of the present study, the percentile groups were enlarged to every 10 percent instead of every 5 percent.

The scores for each student were recorded according to the percentile tables in the Test Manual both with regard to the student's age and with regard to his or her classification index. In cases where the same score was the norm for more than one percentile group (e.g., five pull-ups for a 17-year-old boy was the norm for both the 40th and 45th percentiles), the Danish results coming under this situation were evenly divided between or among the percentile groups involved. In cases where students missed certain of the tests through absence or inability to participate, their remaining test scores were included in the study. Certain difficulty was encountered with the examination schedule at the end of the academic year. As a result of these examinations, approximately 30 girls from the various classes did not participate in the 50-yard dash and the softball throw and 60 girls did not participate in the 600-yard run-walk. The latter number was particularly high because of the inability of one entire class to participate.

Results

The results of the Danish school children are presented according to the number that fell within each of the ten percentile groups for each of the seven activities (Tables 1, 2, 3, and 4). The results of the testing were nearly identical when interpreted either by Classification Index or by age norms and will, therefore, be discussed predominantly in terms of the index (Tables 1 and 3).

The Danish girls exceeded the American averages in all seven of the tests. In the 50-yard dash, 71 percent of the Danish girls equalled or exceeded the American average (50th percentile) score. In this regard, the next best events were the softball throw, the sit-up, the standing broad jump, and the pull-up, where 76 percent, 82 percent, 89 percent, and 90 percent, respectively,

TABLE 1.—PERFORMANCE OF DANISH GIRLS ACCORDING TO PERCENTILE GROUPS AS DETERMINED BY NORMS FOR CLASSIFICATION INDEX

Percentiles	Broad Jump	Pull-up	Sit-up	50 yd. Dash	Ball Throw	Shuttle	600 yd. Run	TOTAL
90-100	52	45	58	14	24	59	56	308
80-89	26	15	16	15	14	32	10	128
70-79	16	29	12	12	19	15	0	103
60-69	14	21	13	11	10	16	1	86
50-59	10	10	8	15	10	6	0	59
40-49	3	8	5	12	10	4	1	43
30-39	5	5	6	9	3	2	0	30
20-29	3	0	4	5	1	0	0	13
10-19	3	0	5	1	8	0	0	17
0-9	0	0	3	0	2	0	0	5
Total	132	133	130	94	101	134	68	792

TABLE 2.—PERFORMANCE OF DANISH GIRLS ACCORDING TO PERCENTILE GROUPS AS DETERMINED BY NORMS FOR AGE

Percentiles	Broad Jump	Pull-up	Sit-up	50 yd. Dash	Ball Throw	Shuttle	600 yd. Run	TOTAL
90-100	48	33	51	14	21	58	54	279
80-89	29	22	27	13	11	33	12	147
70-79	18	30	10	14	19	21	0	112
60-69	13	19	9	14	12	10	0	77
50-59	12	11	6	12	15	6	1	63
40-49	4	10	10	13	8	4	0	49
30-39	2	7	7	6	2	1	1	26
20-29	3	1	3	4	3	1	0	15
10-19	3	0	3	4	8	0	0	18
0-9	0	0	4	0	2	0	0	6
Total	132	133	130	94	101	134	68	792

TABLE 3.—PERFORMANCE OF DANISH BOYS ACCORDING TO PERCENTILE GROUPS AS DETERMINED BY NORMS FOR CLASSIFICATION INDEX

Percentiles	Broad Jump	Pull-up	Sit-up	50 yd. Dash	Ball Throw	Shuttle	600 yd. Run	TOTAL
90-100	136	57	61	26	6	71	129	486
80-89	76	40	31	50	19	70	83	369
70-79	43	32	30	45	27	59	37	273
60-69	23	29	51	55	22	37	16	233
50-59	14	29	25	44	26	27	11	176
40-49	12	41	18	31	30	18	5	155
30-39	11	20	31	21	25	11	3	122
20-29	0	26	29	28	49	1	2	135
10-19	1	26	26	10	62	0	1	126
0-9	1	16	17	5	48	0	0	87
Total	317	316	319	315	314	294	287	2162

TABLE 4.—PERFORMANCE OF DANISH BOYS ACCORDING TO PERCENTILE GROUPS AS DETERMINED BY NORMS FOR AGE

Percentiles	Broad Jump	Pull-up	Sit-up	50 yd. Dash	Ball Throw	Shuttle	600 yd. Run	TOTAL
90-100	126	37	60	30	5	55	118	431
80-89	76	40	28	35	14	59	81	333
70-79	34	45	40	64	21	54	38	296
60-69	29	31	43	33	29	43	27	235
50-59	22	36	22	56	29	31	9	205
40-49	18	32	19	33	44	22	6	174
30-39	9	25	30	25	22	13	6	130
20-29	2	19	38	22	38	10	1	130
10-19	0	28	16	11	63	4	1	123
0-9	1	23	23	6	49	3	0	105
Total	317	316	319	315	314	294	287	2162

of the Danish girls exceeded the American averages. The best results were obtained in the shuttle-run and the 600-yard run-walk where the figures for exceeding the American averages were 96 percent and 99 percent respectively. It is also interesting to note that, in each of five of the tests, broad jump, pull-up, sit-up, shuttle-run, and 600-yard run-walk, over ⅓ of the Danish girls obtained results that equalled or exceeded the American norms for the 90th percentile. The same is true for the age norms, with the one exception of the pull-up test.

While the results of the boys were not quite as spectacular, more than 50 percent of their scores did exceed the American averages in six of the seven events. The only event in which they fell short of the American averages was the softball throw, where 68 percent of the scores were lower than the 50th percentiles. In the pull-up, 59 percent of the Danish scores were as high or higher than the American averages, 62 percent in sit-up, 70 percent in the 50-yard dash, and 90 percent in the shuttle-run. The best results of the Danish boys were in the broad jump, where 92 percent of the scores equalled or exceeded the American averages, and in the 600-yard run-walk, where the figure was 96 percent. It was in these two tests that the amazing totals of 43 percent and 45 percent of the Danish scores fell in the percentile groups for the highest ten percent of the American results.

When the results are totaled within the percentile groups, irrespective of event, the total results show that 86 percent of the 792 girls' scores were in the upper 50 percent of the norms. Approximately 70 percent of the 2162 scores of the boys were in the upper 50 percent. This is graphically shown in Figures I, II, III, and IV. While the use of either the age norms or Classification Index norms makes almost no difference to the number of scores on either side of the mean, the use of the norms for Classification Index does cause an increase in the number of scores falling in the upper fifth of the percentile groups.

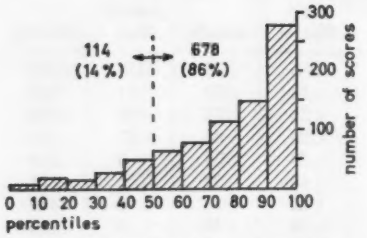

FIGURE I. Danish girls' total performance based on Age Norms.[2]

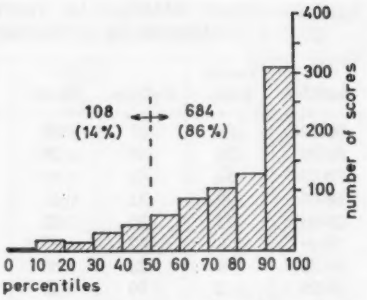

FIGURE II. Danish girls' total performance based on Classification Index Norms.[2]

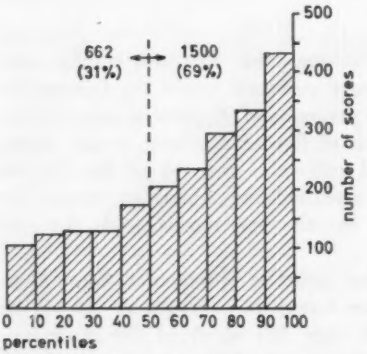

FIGURE III. Danish boys' total performance based on Age Norms.[2]

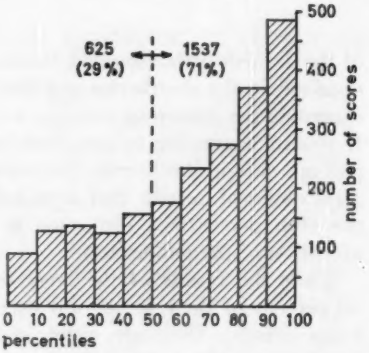

FIGURE IV. Danish boys' total performance based on Classification Index Norms.[2]

In comparing the totaled percentile groups, it was quite interesting to notice the similarity in the dispersion of scores for the two groups of boys who participated. The percentages of scores falling in the ten percentile groups are presented in Table 5 for each of the two schools, both according to age norms and Classification Index norms.

Discussion

The students who participated in this study attend two secondary schools that prepare the highest intelligence group for higher education. The schools are located in suburban Copenhagen and, as this city contains almost one-fourth of the population of Denmark, they can be considered as a fairly

[2]The "Number of Scores" represents the total number of scores from each of the seven tests falling within the various percentile groups. The broken line represents the American mean.

TABLE 5.—PERCENTAGES OF TOTAL BOYS' SCORES FOR EACH OF TWO SCHOOLS ACCORDING TO PERCENTILE GROUPS AS DETERMINED BY AGE AND CLASSIFICATION INDEX

Percentiles	Ordrup Boys (N=209)		Gl. Hellerup Boys (N=110)	
	Age	Index	Age	Index
90-100	20.4	22.8	19.0	21.8
80-89	16.1	17.5	14.1	16.2
70-79	14.2	12.2	12.8	13.4
60-69	10.7	10.5	11.2	11.3
50-59	9.1	8.0	10.3	8.4
40-49	7.9	6.9	8.3	7.7
30-39	6.1	5.8	5.9	5.3
20-29	5.8	6.6	6.4	5.6
10-19	5.4	5.3	6.3	6.8
0-9	4.3	4.4	5.9	3.3

representative group. The fact that they are of a higher level of intelligence than the average should have little or no bearing on the results, according to the findings of Asmussen and Heebol-Nielsen (3). In their study of physical performance and growth in Danish school children, they came to the conclusion that intelligence (IQ) appeared to play no statistically significant role as long as the IQ was higher than 95.

There can be little doubt from the results of this investigation that the group exceeded by far the standards of the American children. In the case of the girls, the performances were little short of amazing. The only event in which the Danish children failed to equal or exceed the American norms was in the softball throw for boys. This is a skill that is rather uncommon to Danish boys' sports (the girls do quite a bit of throwing of a small, rubber ball in a game called longball). Therefore, this result is not unexpected.

It is, of course, impossible to identify the causes for the differences indicated by this study. The only thing that can be done is to attempt to single out the differences in activity in the daily routines of the Danish children as opposed to the American children. There appear to be at least three general differences:

1. There is, by necessity, more activity in the daily life of the Danish child. The bicycle is, of course, the principal means of transportation for the entire Danish population and, as such, comes into use at an early age. When bicycles are not used, a great deal of walking is necessary. Virtually no teen-agers or people in their twenties own automobiles because of the tremendous expense of the imported cars and a government tax of approximately 100 percent of cost. The state-operated television station operates only a few hours a day, usually in the evening, and, therefore, constitutes but a minimum of attraction to sedentary activity.

2. There is a distinct difference in the school physical education programs. The most popular activity in the outdoor programs during the autumn and

spring for boys in soccer. Handball (field-type with goals) and track and field are also used. For the girls, longball and handball are the most popular. All of these activities involve a great deal of running. The winter programs for both boys and girls are devoted to gymnastics, gymnastic-type activities, and, in some instances, occasional ball games. The gymnastic phase involves free-standing movements, activities with light equipment (e.g., for girls, balls, skipping ropes, hoops), and heavy apparatus (parallel bars, booms, vaulting boxes). Physical education classes meet three or four times a week and both the program content and the results are closely followed by school administrators and Education Ministry personnel.

3. There appears to be a much higher interest in sports participation in Denmark. It is difficult to measure and/or generalize because of the lack of similar statistics from the United States but, looking at the figures for sports-club membership and sports participation in Denmark, it is entirely possible that there is a much greater interest on the part of the average Dane in sports. For example, it has been estimated (2) that the total number of active sports participants in Denmark amounts to approximately 45 percent of the total population between 15 and 40 years of age. The number of participants in gymnastics alone corresponds to 12 percent of the population between 15 and 40 and, in soccer, to 25 percent of the male population between 15 and 40.

It must be repeated that it is impossible to determine the degree to which these various factors play a part in causing the obtained differences in test results or, for that matter, if they play a part at all. It would, however, seem safe to assume that since activity is so important in determining fitness and since the great majority of a child's activity takes place in daily routine, the school physical education program, and extracurricular sport interests, considerable consideration should be given to these factors. If the results of this study are to be accepted as further indication of an insufficient level of fitness in American children, the challenge to the American public and to American physical educators is self-evident.

References

1. American Association for Health, Physical Education, and Recreation. *Youth Fitness Test Manual.* Washington, D. C.: the Association, a department of the National Education Association, 1958. 55 p.
2. Andersen, Helge, et al. *Sporten i Danmark i Sociologisk Belysning.* Copenhagen: Det Danske Forlag. 98 p.
3. Asmussen, Erling, and Heebol-Nielsen, K. "Physical Performance and Growth in Children." *Journal of Applied Physiology* 8: 371-80; January 1956.
4. Kraus, Hans, and Prudden, Bonnie. "Minimum Muscular Fitness Tests in School Children." *Research Quarterly* 25: 178-88; May 1954.
5. Kraus, Hans; Prudden, Bonnie; and Hirschhorn, Kurt, "Hypokinetic Disease: Role of Inactivity in Production of Disease." *British Journal of Physical Medicine* 19; August 1956.

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Body Size and Speed

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Abstract

Twenty-one untrained subjects, selected on the basis of body build, were measured for height, weight, speed of a sprint "start," RT as an adjunct of the "start," and simple RT in the laboratory. Analysis of the data permits the conclusion that the speed with which a person can get into action has little relation to his height, weight, calculated body fat, or lean body mass for the population represented by the sample tested.

Review of Literature

A considerable number of investigators over a period of several years have studied the relationships of body size and various measures of speed. The conclusions of these investigators are rarely in agreement. In 1920, Amar (1) posited that people of small stature are quicker than tall ones, because weight decreases as the cube of the size, while force decreases as the square. Cureton (5, 6), however, has stated that people with long legs and arms and relatively short trunks might show great speed and endurance at light athletic work, because long third-class levers are noted for speed and range of motion. Parnell's data (15) indicate that distance runners carry less fat and have longer legs than do participants of such events as shot-put and 100-yd. dash. He characterized the former as ectomorphic mesomorphs and the latter as endomorphic mesomorphs.

A contradictory point of view is presented by Miller (13), who states that his data on the 60-yd. dash provide an excellent indication of the fact that speed is an innate factor not significantly related to body size or build. Cullumbine (4) reported significant positive correlations between measures of body size and time of the 100-yd. dash for 7000 subjects. Concerning weight and the speed of a football charge, Miles (12) has stated that there is some slight evidence to indicate that the heavier a man, the slower he gets into action ($r = 0.22$); Rosenfield (20) reports that there is no significant correlation ($r = -0.08$); and Elbel, Wilson, and French (7) report that there is a significant inverse relationship ($r = -0.51$). These last, however, interpreted the negative correlation as indicating that weight is a handicap to speed for the more experienced player. Miles also found no appreciable correlation between speed of the charge and height ($r = 0.08$).

Coleman (2) and Rarick (18) isolated the following as factors in athletic performance: strength, speed, height, and dead weight (that part of weight which makes no contribution toward strength). Both reported that dead weight acts as an opposing force to speed of muscular contraction, and Rarick, in addition, stated that the height factor appears to be slightly related to sprinting ability and has a slight ngative correlation with reaction time ($r = -0.1060$ for gastrocnemium and $r = -0.1188$ for triceps). Height is also negatively related to reflex time, according to Travis and Young (21). The studies of Westerlund and Tuttle (22) and Lautenbach and Tuttle (11) demonstrated positive correlations between the time of the 75-yd. dash and reaction time ($r = 0.863$) and reflex time ($r = 0.815$), but Henry (8) and Henry and Trafton (9) found no such large correlation between RT and time of the 50-yd. dash ($r = 0.14$ and $r = 0.18$, respectively). Henry (8) also reported that leg length is unrelated to 50-yd. sprinting ability. Pierson (16) found no significant correlation between height, weight, or arm span and simple RT or speed of movement, and Janoff, Beck, and Child (10), after studying the data of

51 Yale University freshmen, concluded that somatotype is not an important determiner of measures of reaction time. It may be that body weight above the lean body mass (roughly comparable to dead weight) has some effect which obscures the relationship of body size to RT and the speed with which an individual can get into action, whether such action be the conditioned response of a trained athlete or the reaction of an untrained subject.

THE AFOREMENTIONED investigations were accomplished on trained subjects, in most cases, trained athletes. The purpose of the present study was to investigate certain relationships between height, lean body mass, body fat, reaction time, and over-all body speed of untrained subjects.

Procedure

Twenty-one selected third-year students of the College of Osteopathic Physicians and Surgeons served as subjects. They were selected to represent the following body builds: short and heavy (under 70 in. tall and over 175 lbs.), short and light (under 70 in. and 160 lbs.), tall and heavy (over 72 in. and 190 lbs), and tall and light (over 72 in. and under 160 lbs.). There were, respectively, five, four, five, and seven subjects in each group. After the subject's height and weight were recorded, simple RT was measured. This involved finger lift in response to a visual stimulus (neon lamp) and, to distinguish it from RT measured in conjunction with over-all body speed, was designated laboratory RT. In accordance with the findings of Pierson and Rasch (17), the mean of the last 5 of 20 trials was used in the computations. The time of a sprint start was used as the measure of over-all body speed.

The apparatus used consisted of a stimulus lamp which was activated simultaneously with a chronoscope, a microswitch which upon release stopped this chronoscope and activated another, and a photoelectric beam, the interruption of which stopped the second clock. Reaction time was then read from the first chronoscope and over-all body speed from the second. Reaction time as thus measured was designated operational RT.

The subject was instructed to assume the position of a sprint start with the right hand holding down the microswitch. On presentation of the visual stimulus, he was to release the switch and run through the photo-electric beam, which was placed chest high and five feet from the switch. Mortenson and Cooper (14) have suggested that untrained runners perform better when the start is made with the stronger leg in front and presented a method for determining the stronger leg. Their suggestion was followed, and the best of five trials was arbitrarily selected as the representative score for operational RT and over-all body speed.

The Rathbun-Pace (19) and Cowgill(3) formulae were applied to the height and weight data for the determination of lean body mass and calculated body fat.

Correlation coefficients for certain of the data were computed, and none was considered as being statistically significant unless the chance occurrence of such a coefficient was 1 percent or less.

Results

The mean scores and sample deviations are presented in Table 1. That over-all body speed is not related to weight, height, body fat, or lean body mass is indicated by their nonsignificant correlations ($r = 0.03$, 0.00, -0.01, and 0.05, respectively). Nor were there any significant correlations for reaction time and these same variables. Laboratory RT correlated with weight, $r = 0.16$; height, $r = -0.02$; body fat, $r = 0.22$; and lean body mass, $r = 0.01$. Correlations of operational RT result in coefficients of 0.29 with weight, 0.12 with height, 0.29 with body fat, and 0.27 with lean body mass. The correlation of operational RT and over-all body speed was not statistically significant ($r = 0.00$), but that of laboratory RT and over-all body speed was ($r = 0.59$). The correlation coefficient of operational RT and laboratory RT was not significantly different from zero ($r = 0.14$).

TABLE 1.—MEAN SCORES AND DEVIATIONS OF BODY SIZE AND SPEED MEASURES

	Weight (lbs.)	Height (in.)	Body Fat (lbs.)	Lean Body Mass (lbs.)	Laboratory RT (sec.)	Operational RT (sec.)	Over-all Body Speed (sec.)
Mean	183.9	70.8	29.54	154.36	0.225	0.330	0.660
SD	35.3	3.0	16.60	20.65	0.026	0.073	0.136

Discussion

The results of the present study may be interpreted as indicating that the speed with which the untrained individual can react has little relationship to his body size or composition. It may be that heavier individuals have accommodated the increased weight by an increase in strength. It should be pointed out, however, that the calculation of body fat and lean body mass, for all practical purposes, can be determined from measures of height and weight only and may not accurately reflect body build or composition.

As previously noted, Westerlund and Tuttle found a significant correlation between reaction time and speed of a short sprint, while Henry and Henry and Trafton reported nonsignificant correlations. That these findings are not contradictory is indicated by the results of the present study. Westerlund and Tuttle, in effect, measured what has been designated in the present study as laboratory RT while Henry and Henry and Trafton measured what has been designated as operational RT, and the present study indicates that there is slight correlation between them. Possible explanation for this low correlation might be found in the greater variability of the earlier trials, which could be interpreted as indicating that some individuals approach optimum speed sooner than others.

References

1. AMAR, J. *The Human Motor.* London: George Routledge and Sons, 1920.
2. COLEMAN, J. W. "Pure Speed as a Positive Factor in Some Track and Field Events." *Research Quarterly* 11:47; May 1940.
3. COWGILL, G. R. "A Formula for Estimating the Specific Gravity of the Human Body with a Consideration of Its Possible Uses," *American Journal of Clinical Nutrition* 5:601; November-December 1957.
4. CULLUMBINE, H. "Relationship between Body Build and Capacity for Exercise." *Journal of Applied Physiology* 2:155; September 1948.
5. CURETON, T. K. "Mechanics of Track Running." *Scholastic Coach* 4:7; February 1935.
6. CURETON, T. K. *Physical Fitness Appraisal and Guidance.* St. Louis: C. V. Mosby Co., 1947.
7. ELBEL, E. R.; WILSON, D.; and FRENCH, C. "Measuring Speed and Force of Charge of Football Players." *Research Quarterly* 23:295; October 1952.
8. HENRY, F. M. "Force-Time Characteristics of the Sprint Start." *Research Quarterly* 23:301; October 1952.
9. HENRY, F. M., and TRAFTON, I. R. "The Curve of Sprint Running." *Research Quarterly* 22:409; December 1951.
10. JANOFF, I. Z.; BECK, L. H.; and CHILD, I. L. "The Relation of Somatotype to Reaction Time, Resistance to Pain, and Expressive Movement." *Journal of Personality* 8:454; June 1950.
11. LAUTENBACH, R., and TUTTLE, W. W. "The Relationship Between Reflex Time and Running Events in Track." *Research Quarterly* 3:138; October 1932.
12. MILES, W. R. "Studies in Physical Exertion: II. Individual and Group Reaction Time in Football Charging." *Research Quarterly* 2:5; October 1931.
13. MILLER, K. D. "A Critique on the Use of the Height-Weight Factors in the Performance Classification of College Men." *Research Quarterly* 23:402; December 1952.
14. MORTENSON, J. P., and COOPER, J. M. *Track and Field.* Englewood Cliffs, N. J.: Prentice-Hall, 1959.
15. PARNELL, R. W. *Behaviour and Physique.* London: Edward Arnold, 1958.
16. PIERSON, W. R. "Comparison of Fencers and Non-fencers by Psychomotor, Space Perception, and Anthropometric Measures." *Research Quarterly* 27:90; March 1956.
17. PIERSON, W. R., and RASCH, P. J. "Determination of a Representative Score for Simple Reaction and Movement Time." *Perceptual and Motor Skills* 9:107; June 1959.
18. RARICK, L. "An Analysis of the Speed Factor in Simple Athletic Activities." *Research Quarterly* 8:89; December 1937.
19. RATHBUN, E., and PACE, N. "Studies on Body Composition: I. The Determination of Total Body Fat by Means of the Body Specific Gravity." *Journal of Biological Chemistry* 158:667; 1945.
20. ROSENFIELD, R. J. "Measuring Reaction Time and Force Extended by Football Players." Master's thesis. Lawrence: University of Kansas, 1950.
21. TRAVIS, L. E., and YOUNG, C. W. "The Relations of Electromyographically Measured Reflex Times in the Patellar and Achilles Reflexes to Certain Physical Measurements and to Intelligence." *Journal of General Psychology* 3:374; July 1930.
22. WESTERLUND, J. H., and TUTTLE, W. W. "Relationship Between Running Events in Track and Reaction Time," *Reseach Quarterly* 2:95; October 1951.

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Effect of Training for Amateur Wrestling on Total Proportional Strength Scores

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Abstract

The total proportional strength test was administered to members of a college physical education class in wrestling, to members of a college wrestling squad before and after training for six weeks, to participants in the 1960 AAU wrestling championships, and to members of the visiting 1959 Japanese champion wrestlers. No significant changes were found in the mean scores of the physical education class or the college squad before and after training. Championship-level wrestlers were stronger than nonwrestlers, but not significantly stronger than those less proficient. The Japanese did not differ significantly from the Americans in strength.

BOTH AMERICAN (2) and European (1, 6) writers have described wrestlers as massive types possessed of great muscular strength, and the importance of a strength factor in tests of the prediction of wrestling ability has been emphasized by Sievers (13) and Gross, Griesel, and Stull (5). Members of the 1956 United States Olympic Wrestling Team commented to one of the authors that part of the reason for the failure of American wrestlers to do better in Olympic competition during the last few years might be the fact that physically they were weaker than wrestlers from certain foreign countries. This observation seems reasonable in view of Kroll's finding that Big Ten wrestlers were below average in grip strength, average in leg strength, and above average only in back strength (7), and that high school wrestlers rated very poorly on strength tests (8). Other studies have shown that the indexes of body build (9) and the calculated body composition (11) of successful American wrestlers do not differentiate them from nonwrestlers.

Under the circumstances, further study of the effects of amateur wrestling on strength seems indicated. The present investigation was devised to clarify the following points: (a) Are candidates for a college wrestling squad stronger than college nonathletes? (b) Does participation on a college wrestling squad increase strength? (c) Does participation in a physical education class in wrestling increase strength? (d) Are wrestlers of championship caliber stronger than wrestlers who have not attained this level? (e) Are U.S. championship caliber wrestlers as strong as wrestlers of a similar level from a foreign country?

Procedure

It is, of course, impossible to measure absolute muscle strength or the total muscular strength of an individual. However, it has been claimed (3) that

four dynamometer tests—right grip, left grip, back lift, and leg lift—when totaled give results which may be considered proportional to the total strength and which can be ratioed into strength per pound of body weight in order to compare individuals of unequal size. Total Proportional Strength (TPS) scores are said to be practically unrelated to cardiovascular measurements, respiratory condition, metabolic rate, time of mile run, and posture, but when they are divided by body weight, high correlations with direct measures of strength and all-round motor fitness test scores result (3). Table 1 shows the means of various groups of athletes and nonathletes as reported in the literature (3, 4, 7).

TABLE 1.—MEAN STRENGTHS OF ATHLETES AND NONATHLETES

Groups	N	Mean Total Proportional Strength	Mean Strength/Weight
Danish Gymnasts	15	1411	8.59
U.S. Track and Field Champions	19	1201	7.79
Big Ten Wrestlers	39	1190	7.42
U.S. Swimmers	17	1129	5.93
Medical College Freshmen	106	905	5.87

During the opening weeks of the fall semester at the University of California at Los Angeles the Total Proportional Strength Test was administered to 21 candidates for the varsity wrestling squad and to an equal number of students in an elective class in wrestling offered as part of the physical education program at the same school.

Hand grip strength was obtained by means of a Jamar adjustable grip dynamometer and leg and back strength by means of a Tiemann & Co. dynamometer. In each instance the testing technique used followed the description given by Cureton (3). During testing, subjects were positioned so that there was an angle of 156 deg. between the femur and the spine at the start of the back lift, and one of 120 deg. between the femur and the lower leg at the start of the leg lift. These measurements appear to be fairly critical and the results of these tests legitimately can be compared only with scores obtained under the same conditions. Scores for TPS and for the individual items comprising the test were divided by body weight in order to make comparisons of individuals of different sizes feasible.

The physical education class met for a one-hour period three times a week for a total of ten weeks, while the college wrestling squad trained for a two-hour period three times a week during the first five weeks of the study and for a two-hour period five days a week during the second five weeks of the study. This period took the wrestling squad from the start of training to its first match.

At the end of the ten weeks both groups were tested a second time and the Wilcoxon Matched-Pairs Signed-Ranks Test was used to evaluate the changes resulting from participation in the two wrestling programs. No statistic was considered significant unless the chance occurrence of such a statistic was 1 percent or less. Table 2 summarizes the data for the physical education class and the college wrestling team at the start of the training program. The difference in numbers in two instances is due to the fact that one of the wrestlers had a sore hand and could not exert full pressure against the dynamometer. The basis for the classification scale used has been described elsewhere (11).

Results and Discussion

Table 3 shows the effects of the two ten-week training programs. Since several of the individuals originally tested had dropped out, been injured, or withdrawn from school, it was necessary to recalculate the before figures to include only those who were available for retesting. Hence, the figures in the before columns in Table 3 differ somewhat from those in Table 2.

The data in Table 2 show that at the start of the two training programs the candidates for the varsity wrestling squad exceeded the students in the physical education class only in the right hand grip. The practice of wrestling three times a week as a physical education activity produced a significant change in the leg strength scores of the physical education students, but this was not sufficient to alter their TPS classification. No significant changes were observed in the strength of the wrestling squad candidates as a result of the much more severe training undergone by the candidates for the varsity wrestling team.

In order to evaluate the possibility that wrestlers of championship caliber might be from a different population than the nonathletes and the wrestlers of ordinary ability, so far as strength was concerned, the figures obtained from the college wrestling squad were then compared with data recorded from 32 participants in the 1960 AAU wrestling championships, all of whom were league, district, or area champions. To compare American wrestlers with a foreign team, data recorded from the 11 men representing the Japanese Amateur Wrestling Association which toured the United States in 1959 were included. The mean scores are given in Table 4. An analysis of variance revealed a significant F of 10.52 with 3 and 80 df. The two extreme estimates of variance did not differ significantly ($F = 1.70$ with 10 and 20 df.), so it was assumed that homogeneity prevailed. Therefore, the significant F may be attributed to differences in the mean scores. Tukey's procedure for the comparison of mean scores in an analysis of variance revealed the following:

1. The TPS scores of the members of the college wrestling squad are not significantly greater than those of the nonathletes.
2. The TPS scores of the participants in the 1960 Amateur Athletic Union championships are significantly greater than those of the nonathletes, but are

TABLE 2.—MEAN STRENGTH/BODY WEIGHT BEFORE TRAINING
(IN POUNDS)

Measures	Physical Education Class				College Squad				Dif. Mean	Sig. Dif. ≤.01
	N	M	SD	Classification	N	M	SD	Classification		
Right Grip/Wt.	21	.692	.126	Average	20	.788	.070	Above Average	.086	S.
Left Grip/Wt.	21	.664	.153	Average	21	.725	.070	Average	.059	N.S.
Leg Lift/Wt.	21	1.948	.726	Fair	21	2.254	.460	Average	.306	N.S.
Back Lift/Wt.	21	2.005	.400	Above Average	21	2.191	.333	Above Average	.186	N.S.
Total Strength/Wt.	21	5.307	1.144	Average	20	5.931	.650	Above Average	.624	N.S.

TABLE 3.—MEAN STRENGTH/BODY WEIGHT BEFORE AND AFTER TRAINING
(IN POUNDS)

Measures	Physical Education Class							College Squad						
	N	Before	Classification	After	Classification	Dif.	Sig. Dif.	N	Before	Classification	After	Classification	Dif.	Sig. Dif.
Right Grip/Wt.	17	.631	Fair	.631	Fair	.000	N.S.	13	.787	Above Average	.742	Average	− .046	N.S.
Left Grip/Wt.	17	.677	Above Average	.638	Average	− .039	N.S.	14	.725	Average	.703	Average	− .023	N.S.
Leg Lift/Wt.	15	1.949	Fair	2.266	Above Average	+ .317	S.	14	2.236	Above Average	2.204	Fair	− .032	N.S.
Back Lift/Wt.	16	2.003	Above Average	2.064	Above Average	+ .061	N.S.	15	2.159	Average	2.463	Very Good	+ .304	N.S.
Total Strength/Wt.	15	5.410	Average	5.794	Average	+ .384	N.S.	12	5.959	Above Average	6.132	Above Average	+ .173	N.S.
Body Weight	15	174.0		175.40		+1.4	N.S.	15	151.9		149.9		−2.0	N.S.

TABLE 4.—MEAN STRENGTH/WEIGHT NON-ATHLETES, COLLEGE WRESTLING SQUAD, 1960 A.A.U. CONTENDERS, 1959 JAWA TEAM

Measures	P.E. Class (N=21)	Classification	College Squad (N=21)	Classification	1960 A.A.U. (N=32)	Classification	1959 JAWA (N=11)	Classification
Right Grip/Weight	.692	Average	.788[a]	Above Average	.732	Average	.934	Excellent
Left Grip/Weight	.664	Average	.725	Average	.674	Average	.898	Above Average
Leg Lift/Weight	1.948	Fair	2.254	Average	3.028	Above Average	2.207	Fair
Back Lift/Weight	2.005	Above Average	2.191	Above Average	2.322	Above Average	2.787	Excellent
TPS/Weight	5.307	Average	5.931[a]	Above Average	6.706	Above Average	6.815	Very Good

[a]N = 20.

not significantly greater than those of the members of the college wrestling squad. Their superiority over the nonathletes may be attributed to their greater leg strength scores.

3. The TPS scores of the Japanese Wrestling Association team are significantly greater than those of the nonathletes, but are not significantly greater than those of the members of the college wrestling squad or of the participants of the 1960 Amateur Athletic Union championships. Their superiority over the nonathletes may be attributed to their greater grip and back strengths.

Some students of wrestling have laid stress on the importance of a strong grip (12). It is certainly true that a strong grip is beneficial to a wrestler and one member of the 1956 Olympic team was still remembered at the 1960 AAU championships for the strength of his grasp. A powerful grip does not appear to be characteristic of American wrestlers, although the Japanese were outstanding in this respect. However, a number of AAU contenders stated that their grip was weak as a result of injuries to the hands sustained in wrestling. In many instances evidence of such damage was clearly visible.

The findings of this study indicate that when it is necessary or desirable to increase the strength of a wrestler, the coach must include some form of progressive resistance exercise in the training program, over and above the actual wrestling workouts.

Conclusions

Insofar as the results of this study are concerned, the following conclusions appear to be justified:

1. Participation in amateur wrestling as a physical education activity or as a member of a college squad is not likely to result in significant gains in strength as measured by the TPS test.
2. Wrestlers of championship levels achieve significantly higher mean scores on the TPS test than do nonathletes, but are not significantly stronger than wrestlers of a lower level of ability.
3. Japanese wrestlers of championship levels do not differ from American wrestlers of a similar level in so far as TPS scores are concerned.
4. Neither collegiate nor championship level wrestlers display outstandingly strong hand grips.
5. The typical American amateur wrestler cannot be described as possessed of great muscular strength.

References

1. Arnold, A. "Korperent Kicklung und Leibesubungen fur Schul und Sportarzle." Cited by Thomas Kirk Cureton, Jr., et al., in *Physical Fitness Appraisal and Guidance*, St. Louis: C. V. Mosby Co., 1947, p. 95.
2. Boardman, Robert. "World's Champions Run to Types." *Journal of Health and Physical Education* 4: 32; May, 1933.
3. Cureton, Thomas Kirk, Jr., et al. *Physical Fitness Appraisal and Guidance.* St. Louis: C. V. Mosby Co., 1947.

4. CURETON, THOMAS KIRK, JR., ET AL. *Physical Fitness of Champion Athletes.* Urbana: University of Illinois Press, 1951.
5. GROSS, ELMER A.; GRIESEL, DONALD C.; and STULL, ALAN. "Relationship Between Two Motor Educability Tests, a Strength Test, and Wrestling Ability After Eight-Weeks Instruction." *Research Quarterly* 27: 395-402; December 1956.
6. KOHLRAUSCH, W. "Zusummenlagne von Korpenform und Leistung-Ergebruise der anthropornetrischen Messungen on der Athleten der Amsterdamer Olympiade." Cited by Thomas Kirk Cureton, Jr., *et al.*, in *Physical Fitness Appraisal and Guidance*, St. Louis: C. M. Mosby, Co., 1947.
7. KROLL, WALTER. "An Anthropometrical Study of Some Big Ten Varsity Wrestlers." *Research Quarterly* 25: 307-12; October 1954.
8. KROLL, WALTER. "Selected Factors Associated with Wrestling Success." *Research Quarterly* 29: 393-406; December 1958.
9. MCCLOY, CHARLES HAROLD, and YOUNG, NORMA DOROTHY. Tests and Measurements in Health and Physical Education. Third Edition. New York: Appleton-Century-Crofts, Inc., 1954.
10. RASCH, PHILIP J. "Indices of Body Build of United States Free Style Wrestlers." *Journal Association for Physical and Mental Rehabilitation* 12: 91-94; May-June 1958.
11. RASCH, PHILIP J. and HUNT, M. BRIGGS. "A Study of the Calculated Body Composition of Amateur Wrestlers." *Journal Association for Physical and Mental Rehabilitation* 13: 90; May-June 1959.
12. RASCH, PHILIP J.; PIERSON, WILLIAM R.; O'CONNELL, GENE; and HUNT, M. BRIGGS. "Norms for the Total Proportional Strength Test." *Journal of the Association for Physical and Mental Rehabilitation* 14: 67-8; May-June 1960.
13. *Scope Weekly*, June 4, 1958.
14. SIEVERS, HARRY L. "The Measurement of Potential Wrestling Ability." Cited by Charles Harold McCloy and Norma Dorothy Young in *Tests and Measurements in Health and Physical Education*, Third Edition. New York: Appleton-Century-Crofts, Inc., 1954.

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Individual Differences in Strength, Reaction Latency, Mass and Length of Limbs, and Their Relation to Maximal Speed of Movement[1]

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Abstract

Data on the maximal speed and reaction latency of limb movements, and the strength and effective mass of these limbs measured in the movement position, were obtained on 70 college men. Individual differences in all measures were highly reliable. Computation of r^2 and k^2 from the intercorrelations reveals that almost without exception the individual differences tend to be highly specific to the particular limb, its direction of movement, and a particular element of the limb action, i.e., strength or speed or reaction latency. The average scores, standard deviations, and the correlation matrix for both functional and anthropometric measurements are included in the report.

EXPERIMENTAL EVIDENCE is accumulating which shows that individual differences in large muscle motor abilities are remarkably specific to the task and the nature of the movement. Bachman (1), using a comprehensive sampling of subjects, has found that there is no appreciable correlation between motor coordination abilities exhibited in two body balancing tasks. Lotter (6) recently reviewed the literature pertinent to the problem of neuromotor and task specificity and explained what is meant by these terms. The later studies he cites, and his own experiments, have largely been concerned with the specificity of speed in explosive large muscle movements of the limbs.

Other current investigations have led to the discovery that individual differences in muscular strength exerted in action do not correlate with static strengths measured in the movement position (4). In explanation, it has been postulated that exertion of force is controlled by a neuromotor pattern which is different, depending on whether the action is static or dynamic. This lack of relationship seems reasonable in terms of the memory drum theory of neuromotor control (2).

Theoretical Considerations; Problem Investigated

This study is concerned with the general problem of securing a basic understanding of individual differences in presumed functional entities such as limb strength or limb speed. As a first approach, this requires a quantitative examination in considerable depth of the amount of generality vs.

[1] From the Research Laboratory of the Department of Physical Education.

specificity in some typical simple neuromotor ability. In the light of the recent studies cited above, a logical hypothesis would seem to be that individual differences are so extremely specific to the details of a particular motor act that the concept of a person being relatively strong (compared with other individuals), or even for example having a relatively strong right leg, is meaningless. Rather, we would have to characterize such an individual as being relatively strong (compared with other individuals) in his ability to exert static force in a certain direction with, for example, his right leg. This would have to be interpreted with the restriction that it does not imply that he will necessarily be able to exert a relatively strong static leg force in some other direction or with another limb, or will be able to exert a relatively strong force dynamically with his right leg so that it produces a fast movement, or will be able to get the movement started quickly.

Such a hypothesis should not be viewed as having an either-or implication; the laws of nature as they apply to individual differences in human performance cannot be expected to give a picture that is all white or all black. The degree of blackness or whiteness (or grayness) must be quantified. Should two directions of movement of a limb be almost identical, one would not expect a measurable amount of directional specificity. If the directions differ by 180 degrees, there should be maximum opportunity for specificity to manifest itself, but we would not necessarily expect that specificity would be complete. Rather, the problem becomes one of determining the actual amount of specificity and of generality that is exhibited by the individual differences in the measurable factors involved in the performance of appropriate motor acts, comparing different limbs, different directions of movement in the same limb, and static vs. dynamic acts within a given limb and direction. It has been shown by others that the appropriate statistical measures are k^2 (specificity) and r^2 (generality), provided that the influence of error variance (unreliability) is removed by the correction for attenuation (1, 3, 5, 6, 7). To establish a reasonable point of reference, it may be argued that motor specificity (k^2) should be considered high if it is greater then the amount of motor generality (r^2).

As delimited to workable form, the investigation has involved the measurement of net reaction time and net speed of movement in both the forward and backward direction, using arm movements in the horizontal plane and leg movements in the vertical plane, the movements being made at maximal speed, and limited to the preferred arm and leg. The effective mass of both the arm and the leg has been determined. Static strength at the start of the movement has been measured for both directions and in both limbs. The resulting scores have been subjected to correlational analysis and applied to the evaluation of the hypothesis outlined above.

Methodology

The subjects, as well as the instruments, movements, and procedures for measuring reaction time and speed, were described in the writer's recent article on the correlation between reaction and movement times (9).

Measurement of Mass and Strength. The effective arm mass was measured as the weight of the extended relaxed arm at the knuckles, considering the arm as a moving lever rotating about the shoulder joint as a pivot. The method was that described by Henry and Whitley (4). Static arm strength was measured by a method similar to the one they used, except that the subject was standing in the position from which he made the horizontal movement rather than reclining. To accomplish this, it was necessary for him to stand within a massive wooden framework (Figure I). With his back pressed against a wide board on the framework, he secured additional stability by bracing a leg against one of the vertical posts and grasping the framework with his free hand. The arm that was being tested for strength pushed against a horizontal lever hinged to the top of an adjustable post that

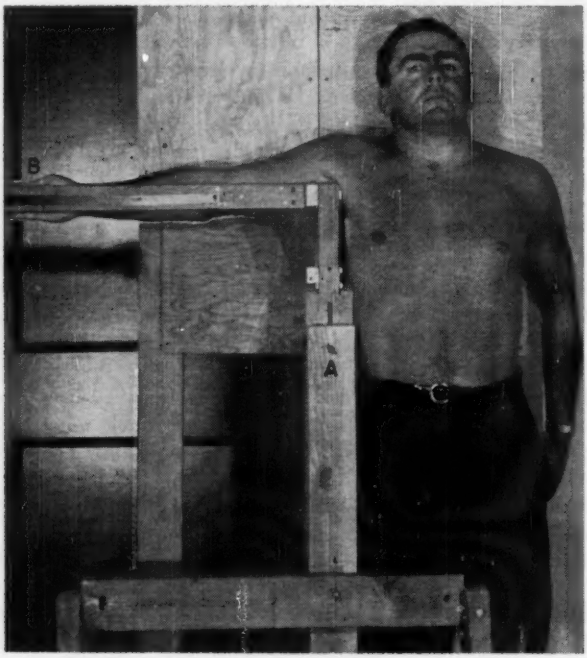

FIGURE I. Measurement of Arm Strength. The subject presses with his hand and forearm against the wooden lever, which is hinged to the back of the vertically adjustable support A, so that the pivot is under the shoulder joint. A triangular masonite brace attached to the lever is hinged lower down for mechanical stability. The dynamometer strap is placed at B. To extend the range of the dynamometer, the strap can be placed further out on the lever, and the reading multiplied by the ratio of the new lever arm to the subject's arm length. In taking the photograph, the hinge support should have been lowered so that the shoulders were level.

was placed directly under the shoulder joint. This permitted the subject to exert his full horizontal arm force, considering the lever as a sort of movable splint placed against his horizontally extended arm. Both the arm forward and arm backward strengths were measured.

Static leg strengths were also measured in the upright posture, with the limb in the position used for initiating the movement in the speed tests. Grasping a heavy table with his hands for stability, the subject exerted his leg force against a fixed dynamometer connected with a cord to the ankle strap. Both the leg forward and leg backward strengths were tested.

Measuring the effective mass of the leg required no specialized apparatus. The subject simply reclined on his back on a table. The apparent mass at the ankle was obtained by supporting the extended relaxed leg, with the small dynamometer strap at the malleolus, holding the instrument by a supporting framework as in the arm mass measurement.

Directly Measured Data. The data available for analysis include the maximal limb speed scores of 70 college men on a 70 deg. (nominal) forward horizontal arm swing and a similar backward arm swing, and a 42 deg. (nominal) forward stiff-legged kick as well as a similar backward leg movement. All of these movements involve the same arc distance for each subject, 80 cm. measured at the knuckles for the arm swing and 70 cm. measured at the toes for the leg kick. The individual scores for each movement are the average of the ten trials that followed three practice trials. Reaction time scores are also available. These consist of the mean of ten trials for each subject. In addition, there are the static arm strengths forward and backward and leg strengths forward and backward, measured in the movement position and direction. The scores for each subject consist of the average of three trials per specified movement, with five min. rest between each measurement. Data for each subject also include the effective arm mass measured at the hand, averaging two trials, and the effective leg mass at the foot, averaging two trials.

Derived Data. These consist of the force/mass ratio scores for each movement and individual. This ratio is proportional to the theoretical speed of movement for each individual and condition, since the force f determines by known physical principles the acceleration that occurs when it acts on a mass m. The conventional physics formula for speed may be rarranged as follows:

$$\frac{f}{m} = \frac{2d}{t^2} \text{ hence } \sqrt{\frac{f}{m}} = \frac{\sqrt{2d}}{t}$$

Note that $\sqrt{2d}$ is constant for all subjects in a particular test, since all moved the same distance, and that Henry and Whitley (4) have shown that the question of whether acceleration is linear is unimportant for correlational purposes. Speed, as they have reminded us, is not an entity— it is the result of a force acting on a mass. Consideration of the above formula reveals that the speed of a movement is a measure of the f/m-ratio where f must

be the force exerted on the mass m during the movement, in order to cause the movement to occur at the observed speed.

The data provide a direct force/mass ratio, namely the ratio of measured strength S to the observed mass M. Therefore, $\sqrt{S/M}$ is a measure that can be correlated with $\sqrt{f/m}$ estimated from the observed speed in order to find the correlation between measured static strength S and dynamic strength f (both strengths being stated in proportion to the individual mass of the arm or leg). The influence of the mass M can, if desired, be removed by direct calculation (under the assumption that the observed M is a valid measure of the true mass m), or it can be removed by the technique of partial correlation, or (if the correlation of m with s and m with speed are low) one can ignore m and simply correlate the observed strength with the observed speed. All three methods were used by Henry and Whitley.

The square roots of the ratios, when plotted as cumulative frequency distributions on probability graph paper, are more nearly linear in trend than is the case of the ratios themselves, although neither is seriously skewed. In the present case, speed is the measure of $\sqrt{f/m}$ that has been used for the correlations. For convenience, the unsquared values of S/M have been given in the tables, although the square roots were used in computing the correlations.

Results

Descriptive Statistics and Reliabilities. The 70 male subjects averaged 23.7 years old ($\sigma = 4.0$). In body description, the mean subject weighed 74.7 kg. ($\sigma = 8.8$), was 180.1 cm. high ($\sigma = 6.43$), had an arm length of 64.2 cm. ($\sigma = 3.4$) measured from the center of shoulder rotation to the knuckles, and a leg length of 101.2 cm. ($\sigma = 5.72$) measured from the center of rotation of the hip to the lateral malleolus. With respect to the preferred arm and preferred leg, which were the ones measured, 84.3 percent of the subjects were right-right, 10.0 percent were left-left, 4.3 percent were left arm-right leg, and 1.4 percent were right arm-left leg as ascertaind by their verbal statement.

The means and standard deviations of both direct and derived performance measures, as well as the uncorrected odd-even reliability coefficients, are given in Table 1. The reliability for arm mass is .970, and for leg mass .976. It is noteworthy that all of the reliability coefficients are relatively high.

The arm strength forward is 15.4 percent greater than the backward strength ($t = 7.7$, significant). The leg strength forward is 10.6 percent less than the backward strength ($t = 5.2$, significant). For each direction, the leg strength is two or three times greater than the arm strength (t's = 39.1 forward and 26.1 backward). The difference in S/M ratio parallels the differences in strength, both as to percent difference and significance.

The arm forward speed is 7.5 percent faster than the backward speed ($t = 3.3$, significant). There is no significant difference in the directional speed of the leg ($t = 1.89$, compared with 2.00 required for the 5% level).

TABLE 1.—MEANS, STANDARD DEVIATIONS, AND ODD-EVEN RELIABILITIES

Factors		Arm fwd.	Arm back	Leg fwd.	Leg back
Strength[a] (kg)	M	13.50	11.70	29.40	32.90
	σ	3.00	2.10	4.50	6.00
	r_{11}	.95	.95	.92	.95
Mass (kg)	M	1.24	1.24	5.07	5.07
	σ	.24	.24	.64	.64
	r_{11}	.96	.96	.98	.98
Ratio (S/M)	M	10.10	8.79	5.84	6.60
	σ	2.78	2.31	.90	1.25
	r_{11}	.94	.95	.93	.94
Speed (cm/sec)	M	547.00	509.00	526.00	510.00
	σ	83.10	81.80	56.70	64.00
	r_{11}	.94	.91	.93	.93
Reaction (sec)	M	.225	.221	.289	.303
	σ	.034	.030	.050	.042
	r_{11}	.870	.880	.950	.91

[a] The gram is a unit of mass; it must be multiplied by 981 to give units of force. These means will therefore have to be multiplied by 981 x 1000 if it is desired to convert them to absolute measures.

Moving in the forward direction, the arm is 4.0 percent faster than the leg ($t = 2.1$, which is significant), but there is no difference in the backward speed of the two limbs ($t = 0.1$). Direction of movement has no significant effect on the reaction time of the arm ($t = 1.6$), but the reaction for the leg is 4.6 percent quicker forward than backward ($t = 3.2$). Comparing the two limbs, the legs react 22.1 percent slower than the arms when the direction is forward ($t = 13.0$), and 27.1 percent slower when the direction is backward ($t = 20.5$). Both differences are obviously significant.

GENERALITY AND SPECIFICITY

Table 2 gives the full-test Spearman-Brown reliabilities in italics as the diagonals of each sub table. Entries above the diagonals are the raw intercorrelations between limbs and between directions of movement. These intercorrelations have been corrected for attenuation in both variables, using the tabled reliability coefficients, and squared to secure the values of r^2 that appear below the diagonals. Multiplying r^2 by 100 gives the percent generality of individual differences, defined as the amount that is common to the two variables used for the correlation. The amount that is specific to each of the two variables ($k^2 \times 100$) is obtained by subtracting the percent percent generality values from 100.

Comparison of Upper and Lower Limbs. In the case of strength, there is 37.7 percent generality and 62.3 percent specificity as between the arms and legs for the forward movement, compared with 30.5 percent generality and 69.5 percent limb specificity for the backward direction. The strength/

TABLE 2.—INTERCORRELATIONS BETWEEN LIMB MOVEMENTS

	Strength[a]				Strength/mass ratio[a]			
	Arm fwd.	Arm back	Leg fwd.	Leg back	Arm fwd.	Arm back	Leg fwd.	Leg back
Arm fwd.	*.973*	.772	.592	.448	*.970*	.721	.457	.312
Arm back	.629	*.974*	.477	.537	.549	*.976*	.376	.433
Leg fwd.	.377	.244	*.956*	.491	.224	.150	*.962*	.494
Leg back	.212	.305	.259	*.973*	.104	.198	.262	*.968*
	Speed[a]				Reaction time[a]			
Arm fwd.	*.969*	.329	.331	.170[b]	*.930*	.809	.587	.657
Arm back	.117	*.953*	.340	.344	.753	*.934*	.478	.617
Leg fwd.	.117	.126	*.965*	.310	.381	.252	*.972*	.705
Leg back	.031[b]	.129	.104	*.963*	.487	.428	.536	*.953*

[a] All correlations except the designated ones are significantly greater than zero ($r = .237$ required at the 5% level). Entries on the diagonals are S-B computed reliabilities, those above the diagonals are raw intercorrelations, and those below the diagonal are r^2 corrected for attenuation.

[b] Not statistically significant.

mass ratio shows a similar situation, with somewhat less generality and greater specificity.

Speed is clearly very specific to the limb. There is 11.7 percent generality and 88.3 percent specificity for the forward movement, compared with 12.9 percent generality and 87.1 percent limb specificity in the backward movement.

Reaction time also tends to be specific to the limb involved in the movement. There is 38.1 percent generality and 61.9 percent specificity for the forward movement, while for the backward movement the figures are 42.8 percent generality and 57.2 percent limb specificity.

Comparison of Directions. In arm strength, there is more generality than specificity between the two directions, 62.9 percent compared with 37.1 percent, although even here the specificity accounts for over a third of the individual difference variance. The legs, however, show high directional specificity, since there is only 25.9 percent generality and the specificity is 74.1 percent. The relationship presents a similar pattern in the case of the strength/mass ratio.

Speed is clearly specific to the direction of movement. For the arms, there is 11.7 percent generality and 88.3 percent specificity; for the legs, there is 10.4 percent generality and 89.6 percent directional specificity.

The reaction time is somewhat more generally characteristic of the limb than of the direction of movement. There is 75.3 percent reaction time generality and 24.7 percent directional specificity for the arm, compared with 53.6 generality and 46.4 percent specificity for the leg. However, it is noteworthy that even for reaction time, from a fourth to nearly a half of the individual difference variance is specific to the direction of movement.

STATIC AND DYNAMIC STRENGTH

Since the speed of movement may be used as a measure of "strength in action" (or dynamic strength) for the purpose of correlational analysis, as explained earlier, we are here interested in the correlation between individual differences in speed and in the strength/mass ratio, and also in the correlation between speed and strength independent of the factor of mass. It should be emphasized that in this analysis, as in the preceding one, there is only minor interest in whether the correlations differ significantly from zero, since with 70 subjects the coefficients that pass the conventional test of statistical significance may be so low as to represent only a trivial amount of relationship. The figures of primary concern in this investigation are the *amounts* of relationship as revealed by r^2, having first removed statistically the small amount of unreliability present in the raw score correlations.

Strength and Speed. The correlations between these variables for each limb and direction are given in Table 3. As indicated above, the speed is interpreted as "strength in action," although this interpretation is not crucial to the purpose of the study. The amount of generality of function, with respect to individual differences in the two variables, is revealed by the table to be so low as to be negligible. The highest amount of generality is 7.6 percent in the arm movement forward; the corresponding amount of specificity is 92.4 percent. The correlation for this particular movement is statistically significant. For the other movements the correlations do not differ significantly from zero.

Strength/Mass Ratio and Speed. This ratio appears to offer a theoretically more exact method of scoring the observed static strength in a manner that is comparable to the "strength in action" scored by the limb speed measurements. The results in Table 3 show that there is no more than a negligible amount of generality between the two variables. In this analysis, the highest amount of generality, 7.4 percent, is found for the leg forward

TABLE 3.—CORRELATIONS OF STRENGTH AND STRENGTH/MASS RATIO WITH SPEED

		Strength				Strength/mass ratio			
		Arm fwd.	Arm back	Leg fwd.	Leg back	Arm fwd.	Arm back	Leg fwd.	Leg back
Correlation with speed (raw)	r	.267[a]	.223	.222	.134	.122	−.040	.272[a]	.102
Common variance with speed[b]	r^2	.076[a]	.054	.053	.019	.015	.002	.074[a]	.010
Partial correlation with speed[b] (mass held constant)	r^2	.062[a]	.036	.063[a]	.020	—	—	—	—

[a] The designated coefficients differ significantly from zero ($r = .237$ or $r^2 = .056$ required at the 5% level).
[b] Correlations were first corrected for attenuation caused by unreliability.

movement. The corresponding specificity is 92.6 percent. The correlation coefficient for this one movement is statistically significant. The other movements do not produce correlations that differ significantly from zero.

Partial Correlation with Speed. When the influence of mass is held constant by the partial correlation method, using the corrected coefficients, the correlation between strength and speed is .249 for the arm forward and .251 for the leg forward. Both of these are conventionally significant, although the amount of relationship is very low as indicated by the r^2 values given in Table 3. The partial correlations for the backward movements, namely .190 for the arm and .142 for the leg, do not differ significantly from zero. It makes little difference whether one uses the correlation of speed with strength or the S/M ratio, or computes the partial correlation. The relationship remains extremely low.

Reaction Time and Speed. These data were reported in the author's previous study (9). The relation between the two variables, computed as the RT-MT correlation, ranged from —025 to .236 after correction for attenuation and did not differ significantly from zero in any of the movements. Thus the measured generality of individual differences in "quickness" as between the reaction phase of a limb movement and the overt phase of the movement ranged from zero to 5.6 percent; the specificity ranged from 94.4 to 100.00 percent.

ANTHROPOMETRIC RELATIONSHIPS

Since leg kicks and arm swings (both forward and backward) occur in many sports or other activities, it is of value to present the intercorrelations of the strengths, limb measurements, and body size. While only certain ones of these are of present interest, the correlation matrix (Table 4) has been completed so that other types of analysis can be made if desired.

Limb mass has considerable correlation with total body weight, being $r = .644$ for the arm, $r = .739$ for the leg, and $R = .785$ when the two limb masses are combined. This finding tends to support the validity of the method of limb mass measurments, particularly for the legs, since it would be difficult to account for these correlations on any other basis. This view is strengthened by the fact that when the influence of limb length is added to limb mass by the multiple correlation technique, there is no appreciable increase in the correlation with body weight—$R = .654$ for the arm and $R = .745$ for the leg.

In this college age group, large men show a slight tendency to be stronger in the arm or leg than smaller men. The correlation of weight with strength ranges from .426 for leg backward to .562 for leg forward. These correlations do not measurably increase when the influence of height is added by using multiple correlations. There are low but significant correlations between limb mass and limb strength, ranging from .311 for leg backward to .498 for leg forward. When limb length is added by the

TABLE 4.—CORRELATION MATRIX OF ANTHROPOMETRIC RELATIONSHIPS[a]

		H	L_a	L_l	W	M_a	M_l	S_{af}	S_{ab}	S_{lf}	S_{lb}
Length											
Body	H		.677	.750	.653	.443	.621	*.189*	.309	.356	.262
Arm	L_a	.677		.743	.355	.383	.402	*.031*	*.142*	*.088*	*.112*
Leg	L_l	.750	.743		.485	.309	.547	*.154*	.284	.299	*.234*
Mass											
Body	W	.653	.355	.485		.644	.739	.467	.531	.562	.426
Arm	M_a	.443	.383	.309	.644		.583	.330	*.209*	.357	*.166*
Leg	M_l	.621	.402	.547	.739	.583		.339	.432	.498	.311
Strength											
Arm fwd.	S_{af}	*.189*	*.031*	*.154*	.467	.330	.339		.772	.592	.448
Arm. bk	S_{ab}	.309	*.142*	.284	.531	*.209*	.432	.772		.477	.537
Leg fwd.	S_{lf}	.356	*.088*	.299	.562	.357	.498	.592	.477		.491
Leg bk.	S_{lb}	.262	*.112*	*.234*	.426	*.166*	.311	.448	.537	.491	
Speed											
Arm fwd.	V_{af}	*−.111*	*−.217*	*−.194*	.253	*.122*	*.109*	.267	*.171*	*.043*	*.235*
Arm. bk.	V_{ab}	*−.095*	*−.199*	*−.050*	*.112*	*.236*	*.116*	.307	*223*	*.087*	.243
Leg fwd.	V_{lf}	*−.006*	*−.337*	*−.216*	.251	*.088*	*.030*	.279	*.200*	*.222*	.321
Leg bk.	V_{lb}	*−.038*	*−.126*	*−.070*	*.110*	*.226*	*.010*	*−.018*	*−.008*	*.004*	*.134*

[a] Correlations printed in italics (those below .237) fail to reach statistical significance at the 5 percent level. Reliabilities for arm and leg length, height and weight are .990 or higher; for the other measures the reliability coefficients have been given in the other tables. Intercorrelations among the speed measurements appear in Table 2.

multiple correlations technique, the increase in relationship is hardly discernable, since the R values are only .320 to .499.

Taller men show a moderate tendency to be long-limbed as compared with shorter men. The correlation of height with arm length is r = .677, with leg length it is r = .750, and with the limbs combined it is R = .767. A better perspective can be gained by converting these correlations into percentages of individual difference variance. Limb length shows 55.2 percent generality and 44.8 percent specificity as between the two limbs. With respect to body height, the arm has 45.8 percent length generality and 54.2 percent limb specificity, while the leg has 56.3 percent length generality and 43.7 percent specificity. Thus individual differences in long-leggedness or long-armedness are just about as much specific to the particular limb under consideration as they are characteristic of the tallness or shortness of the individual, or the longness or shortness of his upper (or lower) limb.

Discussion

Some of the data of the present study can be compared with the factual findings of other investigators. Lotter (5), testing a sample of male undergraduates, used a right arm downward swing and right leg forward kick. While the stimuli and movements differed, so that comparison of averages in his study and in this one would be pointless, the pattern of the results can be compared. Both reaction times and speeds of movement were slower for

the leg as compared with the arm. He found an arm-leg correlation of .521 for reaction time and .287 for speed of movement. In this study, the corresponding correlations are .587 and .331 and do not significantly differ from his ($t = 0.6$ and 0.3). The results therefore confirm the findings of Lotter and present the additional facts of relatively high directional specificity of limb movement reaction times and speeds (Table 2).

Henry and Whitley (4), testing a sample of right-handed males four years younger than the subjects in this study, used a horizontal arm swing. They reported relevant anthropometric data. Their sample averaged 7.3 percent heavier than this one ($t = 2.9$) but did not differ significantly in height ($t = 0.6$), arm mass ($t = 0.9$), arm length ($t = 1.9$), or speed of arm movement ($t = 0.6$). The mean reaction times of the two studies cannot be compared since different stimuli were employed; neither can the mean arm strengths, since the present "standing strength" method is known to yield lower values than their method. The major finding is, of course, the almost complete absence of correlation between speed of arm movement and strength. In their study these correlations were so low as to be nonsignificant (.189 and .153); in the present investigation they are also very low (.267 and .210), although one of these does differ significantly from zero. The results with the strength/mass ratio also agree in showing little or no correlation with speed. The Henry-Whitley findings on this part of the problem are therefore confirmed and are extended by the present study to apply to other directions of movement and other limbs, as well as a different method of measuring strength.

With respect to the large amount of directional specificity and limb specificity of strength, it should be mentioned that these findings have unknowingly been adumbrated by the work of others, although the "sports type" of limb actions used in this study have apparently not been of much interest to strength testers. Most researchers in this area have evidently been impressed with the existence of moderate amounts of positive correlation between the strengths of various parts of the body and have never realized that there might, in general, be more specificity than common strength element.

Perhaps the most recent report of intercorrelations between different strengths is that of Seymour (8), who measured the hand grip, back lift, leg lift, and Rogers arm strengths of several hundred senior high school boys in Massachusetts and compared them with data from several hundred Oregon boys. The relationships he found were typical of the results of previous studies. Seymour was not interested in strength specificity, but we may use his correlations to compute it. Excluding for the moment the comparison of right hand vs. left hand grip strength, and assuming that the reliabilities are high, the specificity ranges from 67.5 to 85.6 percent; the generality of the static strength function ranges from 14.4 to 32.5 percent. Comparing now the right and left grip strengths, there is 48.2 percent bilateral specificity and 51.8 percent hand strength generality in the Oregon

boys, compared with 55.1 percent specificity and 44.9 percent generality in the Massachusetts boys. These are very close to the values of 53 percent specificity and 47 percent generality of grip strength in college men recently reported by Henry and Smith (3).

On the basis of the evidence obtained in the present study, the hypothesis stated in the introduction is strongly supported. Individual differences in limb action abilities (considering reaction latency, strength, and speed as the components of such action) tend to be highly specific to the component, to the limb involved in the action (arm vs. leg), the direction it is moved (forward vs. backward), the dynamic or static nature of the action (speed vs. measured strength), and the phase of the action (reaction latency vs speed of movement). For some of the findings, cross-validation using other published data is available and lends additional support to the hypothesis.

Summary and Conclusions

Measurements of maximal speeds of arm swings in the horizontal plane and stiff-leg kicks in the vertical plane were made for both the forward and backward directions in 70 male college students. Reaction times and static strengths in the movement position were also measured. Anthropometric measurements included effective mass of the arms and legs as well as limb lengths, stature, and weight. Reliability of individual differences in all the measures was high. Interpretation of the intercorrelations among the individual scores has led to the following conclusions concerning arm and leg action abilities. It is to be understood that these conclusions are tempered by the usual restrictions imposed by the inescapable fact that only certain movements and individuals were studied and that only a limited number of cross-validation checks on the validity of the findings were available.

1. Individual differences in ability to make a quick reaction are somewhat more specific to the reacting limb than characteristic of the general limb reaction ability of the individual. Along with the specific limb reaction ability, there is a considerable amount of directional specificity.

2. Individual differences in maximal speed of limb movement are highly specific to the limb, and highly specific to the direction of the movement (forward or backward). Apparently, speed of limb movement ability as an entity characterizing the individual does not exist to any important extent.

3. Individual differences in limb strength tend to be specific to the limb; there is approximately twice as much limb specificity as there is arm-leg generality. Leg strength is characterized by high directional specificity, while arm strength seems to exhibit somewhat more generality than directional specificity.

4. Individual differences in speed of limb movement (i.e., strength in action) are almost completely unrelated to measured static strength or the ratio of static strength to limb mass.

5. Individual differences in limb mass are substantially correlated with

total body mass. There is a low but consistent tendency for strength of limbs to be related to amount of limb mass or total body mass.

6. Long- or short-limbedness is about equally a general characteristic of the individual and a specific characteristic of the individual limb (arm or leg).

References

1. BACHMAN, J. C. "Specificity vs. Generality in Learning and Performing Two Large Muscle Motor Tasks." *Research Quarterly* 31: 3-11; March 1961.
2. HENRY, F. M., and ROGERS, D. E. "Increased Response Latency for Complicated Movements and a 'Memory Drum' Theory of Neuromotor Reaction." *Research Quarterly* 31: 448-58; October 1960.
3. HENRY, F. M., and SMITH, L. E. "Simultaneous vs. Separate Bilateral Muscular Contraction in Relation to the Neural Overflow Theory and Neuromotor Specificity." *Research Quarterly* 31: 42-46; March 1961.
4. HENRY, F. M., and WHITLEY, J. D. "Relationships between Individual Differences in Strength, Speed, and Mass in an Arm Movement." *Research Quarterly* 31: 24-33; March 1960.
5. LOTTER, W. S. "Relationships among Reaction Times and Speeds of Movement in Different Limbs." *Research Quarterly* 31: 147-55; May 1960.
6. LOTTER, W. S. "Specificity or Generality of Speed of Systematically Related Movements." *Research Quarterly* 31: 55-62; March 1961.
7. MENDRYK, S. "Reaction Time, Movement Time and Task Specificity Relationships at Ages 12, 22 and 48 Years." *Research Quarterly* 31: 156-62; May 1960.
8. SEYMOUR, E. W. "Follow-up Study on Simplifications of the Strength and Physical Fitness Indexes." *Research Quarterly* 31: 208-16; May 1960.
9. SMITH, L. E. "Reaction Time and Movement Time in Four Large Muscle Movements." *Research Quarterly* 31: 88-92; March 1961.

(Submitted 8/11/60)

Design of Football Helmets[1]

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Abstract

The energy attenuating abilities of a series of commercially available football helmets and of several experimental helmets have been studied using accelerometer test equipment. Marked differences were demonstrated, and appreciably superior performance was found in prototype helmets using energy absorbing foamed plastic inner liners. Confirmation of these data has been obtained through limited field trial under actual practice and game conditions at the Davis campus of the University of California.

SEVERAL YEARS AGO, a group of men interested in sports car racing established a nonprofit research organization for the study and testing of protective devices used in the field of racing. This, the Snell Memorial Foundation, has rapidly grown beyond the auto racing field in which it began. Its initial studies of racing crash helmets have been extended to a number of other areas in which there is a potential for head trauma.

Shortly after the establishment of the Foundation's present test facility at the Davis Campus of the University of California, the opportunity to study football headgear arose. The Physical Education Department of the University, properly concerned with a series of head injuries among the football squad, was interested in an evaluation of football helmets currently on the market and in the possibility of developing a more adequate head protective device. This was an immediate parallel to the work of the Foundation then in progress with crash helmets designed both for racing and for the Armed Forces personnel, and allowed the use of established techniques and equipment.

In this study, problems more pertinent to racing and military needs, such as protection against penetration and abrasion, and tests of strap and harness strength, were disregarded. The primary area of concern was that of protection against the accelerative effects on the brain of high levels of impact energy. This development is perhaps the most significant effect of the application of impact energy to the head in the production of cerebral concussion and brain damage (1).

Energy levels which are of a fatal order of magnitude if applied to an unprotected head may easily be reached in a body contact sport such as football. Simply falling to the ground in such fashion so as to strike the head

[1] This study was made possible in part by research grant RG-6094 from the National Institutes of Health.

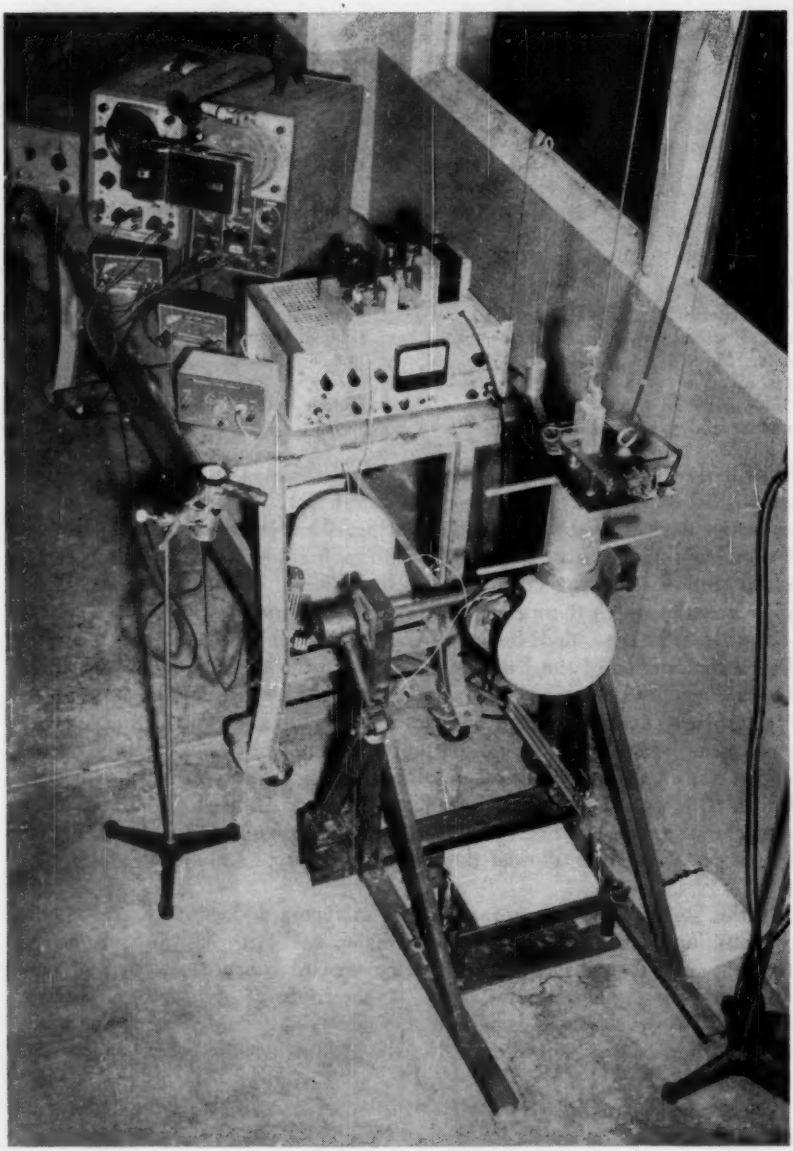

FIGURE 1. Snell Memorial Foundation impact testing facility, University of California, Davis, California.

directly may develop up to 100 foot pounds of energy in an average-sized adult. Comparable forces can be developed by a blow from a knee or an elbow. Fortunately, most impacts incurred during a football game are of a considerably lower level of energy, but deaths due to football occur annually, and approximately three-quarters of such deaths are due to head injuries (2).

Materials and Method

Eleven different models of football helmets obtained from the open market and a series of experimental prototype helmets have been studied by the Snell Foundation.

The efficiency of a helmet in attenuating impact energy is determined in the following fashion. The helmet to be studied is placed upon a metal test head in which is fitted a crystal-type accelerometer. A known amount of impact energy is applied by dropping upon it a striking bob; the weight of this bob and the height of its drop are easily varied. The head support pivots upon impact, thus providing for an essentially free-moving mass. Acceleration

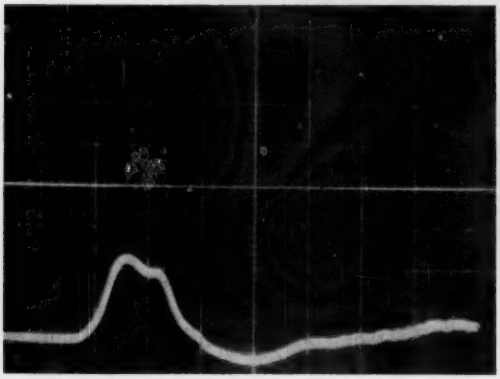

FIGURE II. Acceleration time history tracing showing low peak acceleration and broad time base. Acceleration shown on ordinate, 50G/division. Time recorded on abscissa, 2 milliseconds/division.

imparted to the test head is translated into an electrical impulse, magnified by an amplifier, impressed upon the screen of a cathode ray oscilloscope, and photographed by a Polaroid Land camera. The resulting tracing, obtained after proper calibration of the equipment, appears as in Figure II.

In these tracings, acceleration, expressed as gravitational units, or G's, is registered on the vertical axis, with the horizontal axis representing a time base. Figure II s hows an example of excellent energy attenuation, with a low order of developed acceleration and with the energy being dissipated over a broad base in terms of time.

Figure III illustrates the effect of impact of a helmet which provides for very poor energy attenuation. Here, there is a rapid development of very high level of acceleration, greater than 400 G's, over a very short time inter-

val. In addition, it demonstrates an after-vibration resonance, referred to as "bottoming." This develops when there is solid contact of the striking bob with the headform, and at this point there is essentially complete transmission of energy with consequent loss of protection.

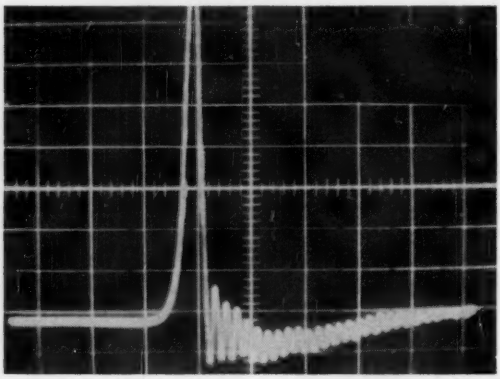

FIGURE III. Acceleration time history tracing showing high peak acceleration with rapid onset, and after-resonance, or bottoming effect.

Results of Comparative Testing

Most football helmets now sold utilize a sling suspension as their "first line of defense" in energy dissipation. If well-designed, such a system handles impact energy quite well indeed, if the point of impact is at or relatively near the crown of the helmet. However, since deflection of a helmet shell occurs upon impact, blows upon sites removed from this coronal locus produce solid contact, or "bottoming," at much lower energy levels. This inward deflection of the shell, with a consequent relaxation of the sling suspension and development of solid contact between shell and head, is shown in Figure IV. This shows two frames of a high-speed motion picture of a test impact, immediately prior to contact and at the point of near-maximum inward deflection (3).

The difference in energy handling ability of a sling suspension system between different points of impact is illustrated graphically in Figure V. Here, the excellent efficiency of handling a blow high on the helmet, at a point where the sling is able to spread the load of the blow, is contrasted with the poor efficiency of the same system impacted at a lower point, away from the coronal locus of maximum efficiency.

Experimental Studies

A transfer of knowledge gained from a much broader experience with racing crash helmets suggested the interposition of other energy attenuating systems between shell and head than the conventional sling suspension. One of the more effective sling suspension-type football helmets was tested with two different types of energy handling liner material.

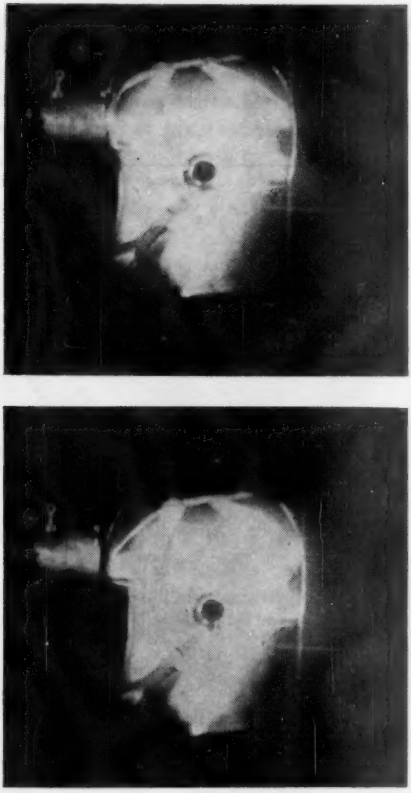

FIGURE IV. Shell deflection, with sling suspension failure on impact.

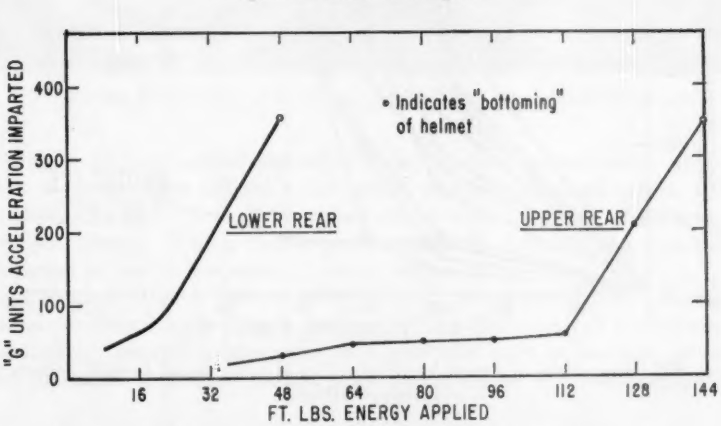

FIGURE V. Difference in energy attenuation at 2 sites of impact in sling suspension type helmet.

In Figure VI the energy attenuating ability of the sling system alone is shown in comparison with the same helmet fitted with a semi-resilient or slow-rebound type liner. An appreciable gain in performance is noted. Also shown is the same helmet fitted with a similar thickness of a nonresilient foamed plastic liner. An even greater gain in performance is demonstrated.

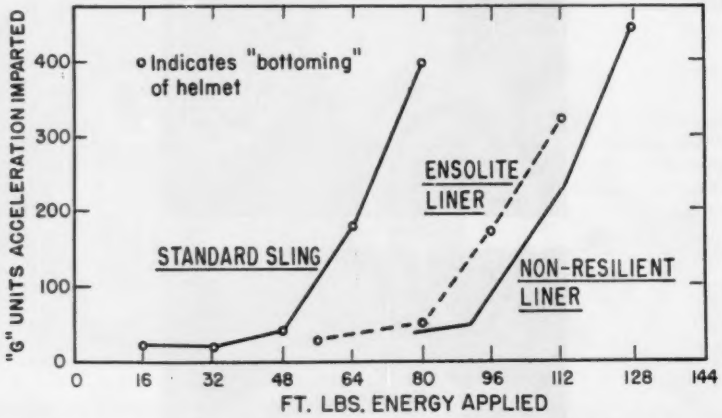

FIGURE VI. Comparison of energy attenuating ability of sling suspension, slow-rebound liner, and non-resilient liner.

We have found, in other studies of high energy impacts, that a sufficient thickness of slow-rebound material to attenuate adequately such energy adds a bulk and weight which often exceeds the limits of practicality. A properly selected density of one of the polystyrene or urethane families of foamed

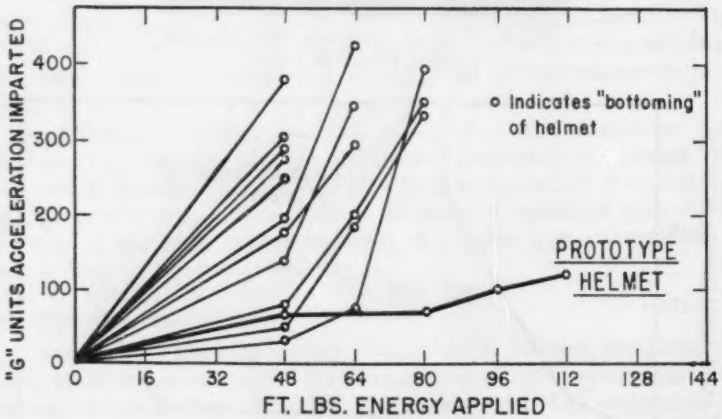

FIGURE VII. Comparison of energy handling ability of conventional football helmets and prototype helmet.

plastic provides adequate protection with light weight and low bulk. If used in conjunction with either a sling suspension or a thinner layer of slow-rebound material, both the common, low-energy blows and the less frequent, severe impacts are handled with comfort and safety.

A comparison of the energy handling abilities of the 11 models of conventional football helmets studied with that of one of the prototype experimental helmets is shown in Figure VII. This illustrates the acceleration imparted to the test head at relatively low energy levels and shows the points of bottoming, or solid contact failure. The superior performance of the energy attenuating system of the experimental helmets is well demonstrated. The prototype helmet used in this study is shown in Figure VIII.

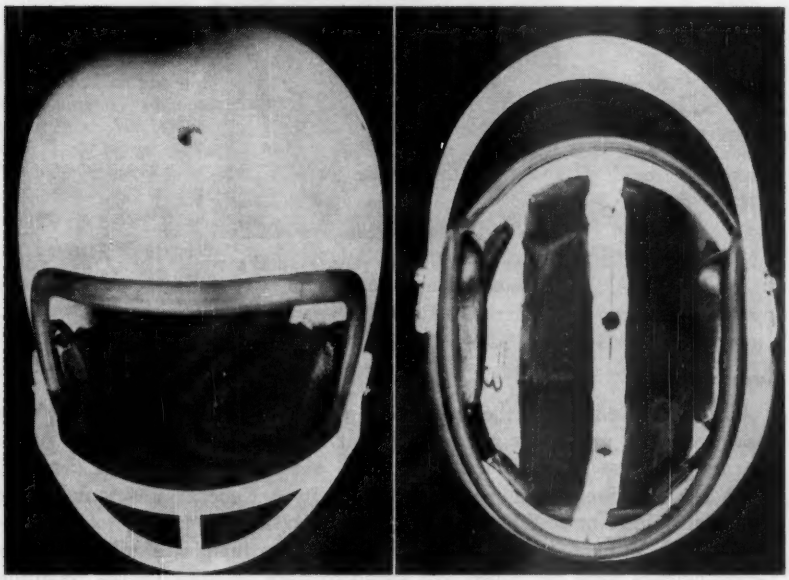

FIGURE VIII. Views of inside and outside of prototype football helmet.

Figure IX is a sagittal section of a racing crash helmet which shows the type of construction utilized in the prototype football helmets which we have studied. An outer shell of fiberglass covers a ½ in. layer of foamed, non-resilient plastic. Within this is padding of soft, slow-rebound plastic foam designed to handle low energy impacts with comfort.

A number of such helmets have had field usage under both practice and game conditions at the Davis Campus of the University of California, and preliminary observations suggest an appreciable gain in comfort, as well as the increased protection against high energy blows to be anticipated from

laboratory studies. Further work is continuing, and it is felt that the development of a near optimum head protective device for football players is close at hand.

FIGURE IX. Cutaway view, sagittal section, of prototype helmet, showing liner construction.

Summary

A comparative study of the protective qualities of football helmets has been presented. The parameter of measurement has been the acceleration of an instrumented test head upon impact. The ability of a group of commercially available football helmets to attenuate impact energy was found to be appreciably inferior to that of several racing crash helmets. Prototype football helmets utilizing energy absorption design principles similar to these racing helmets were developed and found to have superior energy handling ability in the laboratory. Actual field trial under both practice and game conditions of these prototype helmets has indicated an appreciable gain in comfort as well as an increased protection against high energy impact on the head.

References

1. DENNY-BROWN, D., and RUSSEL, W. R. "Experimental Cerebral Concussion." *Brain* 64: 93; 1941.
2. Committee on Injuries and Fatalities, American Football Coaches Association. *Twenty-Eighth Annual Survey of Football Fatalities.* American Football Coaches Association: 1958.
3. ROTH, H. P. Personal communication.

(Submitted 6/28/60)

Physical Performance, Skinfold Measurements, Activity Expenditures, and Food Consumption of College Women[1]

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Abstract

Members of an incoming college class enrolled in a physical education and physical therapy program were used to determine physical fitness and caloric intake and output. These data, related to results found at the end of an increasingly active year, showed that better physical performance was exhibited and that caloric intakes paralleled the increase in exercise, while weight was maintained. Of the subcutaneous fat measures made at several sites, weight loss was most reflected in loss of scapular and abdomen skinfold thickness; the opposite did not hold true for weight gain.

THE IMPORTANCE OF exercise for improved physical performance and its relationship to the balance of calories consumed as food are well recognized (3,7). While stepped-up physical activity has been minimized by some as a means of weight control on the grounds that increased exercise augments appetite, which in turn leads to a weight gain, this has been shown not to be so in animals (8) or in adult man (9). In the present study the physical performance, caloric intake, and activity expenditure of physical education and physical therapy students were determined upon their entrance to college and again at the close of their first academic year. The changes in weight and subcutaneous fat tissue were also noted. The nature of the first year curriculum exposed the students to a progression of exercise during the school season which ended in a vigorous activity schedule for four weeks at a spring camp. The basic activity program of the physical education students included fundamentals of physical education, swimming, rhythmic analysis, ballroom dance, and basketball, while the program of the physical therapy students included only swimming and fundamentals of physical education. Both of these programs are in contrast to the year-end intensive four-week program in sports and skills. These two periods differed widely in the demand for caloric expenditure and

[1] Supported in part by grants in aid from the National Institute of Arthritis and Metabolic Diseases (A-2839), National Institutes of Health, U. S. Public Health Service, Bethesda, Maryland; The Nutrition Foundation, Inc., New York; and the Fund for Research and Teaching of the Department of Nutrition.

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provided an opportunity to make observations of the effect of activity on weight control and physical performance.

Subjects and Procedure

The data were collected on members of the incoming class of Sargent College, the women's school of physical education and therapy of Boston University. A smaller group of 27 students was used for making paired comparisons of observations.

Body Measurements. Weights were taken to the nearest ¼ lb. without shoes or outer clothing. Heights were recorded to the nearest ¼ in. without shoes. Relative weight, actual body weight expressed as a percentage of "standard" weight for height and age, was calculated from the Medico-Actuarial Mortality Investigation of 1912 (10). Subcutaneous fat was measured to the nearest ½ mm. and upper arm circumference, in cm.

Skinfold thickness measurements were made with a constant pressure caliber (Harpenden) having a contact surface of 40 mm.[3] Measurements were taken on the right side of the body at the following sites.

1. Arm, flexor, and extensor surfaces; at a midanterior and midposterior point half way between the acromion and the tip of the elbow. The forearm was held in 90 deg. flexion and the fold was held parallel to the long axis of the arm.
2. Scapula; below the tip of the scapula. The skinfold was lifted to form a 45 deg. angle from the tip of the scapula to the spine.
3. Abdomen; at the midaxillary line midway between the ribs and iliac crest. The skinfold was lifted parallel to the midaxillary line.

The skinfold measurements were expected to decrease in case of weight loss and increase in case of weight gain, therefore one-tailed sign tests (13) were used to obtain the associated probabilities of occurrence of changes in these directions.

Physical Performance Tests. The Harvard Fatigue Laboratory step test (2) was used as a measure of physical fitness. This test measures the rate of recovery of the heart in the minute and a half following four minutes of standard exercise. The subjects are then rated according to a scale based on postexercise pulse rates.

Physical Activity Records. Activity records were kept for five consecutive weekdays during the fall semester. The time spent in each activity was recorded by the student, along with her estimation of the intensity of the activity (light, moderate, severe). The level of ability (beginning, intermediate, advanced) in a given sport or dance activity was also recorded.

A one-day record of activities was kept by the students during the June camp session. The records were staggered so as to cover approximately equally each week day of a two-week period. Unlike the procedure for the first semester activity records, the amount of time spent in sitting, standing, or moving was able to be judged by an observer during class hours in order to obtain a more precise estimation of the time and the severity of each

[3]The assistance of Beno Vajda in measuring skinfold thicknesses is gratefully acknowledged.

activity performed. Values compiled by Passmore and Durnin (11) were used for calculating the caloric cost of the various activities.

Food Intake. During the fall semester, diet records were kept by each student for seven consecutive days. In order to obtain an estimate of food consumption in the spring camp, one-day food records were kept by the students at the same time the activities were recorded. Caloric intakes were calculated from standard tables of food values (1,14).

TABLE 1.—FREQUENCY DISTRIBUTION OF INDEXES OF PHYSIOLOGICAL RECOVERY FROM EXERCISE[a]

Index Score	Time of Test	
	Early School Year (No. Subjects)	Spring Camp (No. Subjects)
10-20	3	1
21-30	6	1
31-40	19	5
41-50	7	7
51-60	16	12
61-70	13	21
71-80	1	7
81-90	0	4
	Total 65	Total 58

[a] Harvard Fatigue Laboratory Step Test (2).

Results

A glance at the frequency distribution chart in Table 1 shows that the index scores of physiological recovery from exercise improved at the end of the year. Endurance to exercise also improved. Of the 65 students who took the first test, 34 percent completed the four-minute exercise test. However, of the 58 who took the second test while at camp, 71 percent were able to complete the four-minute test; this included 51 students who took the first test at school. Twenty-two students completed the entire four-minute test during the first trial early in the school year and again completed the test at the end of the year. Paired comparisons of the difference for either the 22 twice-completed or the 51 twice- or partially-completed tests in school and camp periods showed a highly significant (t of $<1\%$) improvement in the index of physiological recovery from exercise.

The combined average daily caloric expenditure from the weekday school records on 42 students, as well as the average estimated time spent in separate activities, are tabulated in Tables 2 and 3. The activities were classified as requiring 150 Cal./hr. or less, 151-250 Cal./hr., and over 250 Cal./hr. The average expenditure estimated for the entire group was 2514 calories.

Forty-one of the 42 students completed a seven-day diet record. Eight of the records were representing intakes, judged by the students themselves,

TABLE 2.—AVERAGE DAILY ESTIMATED CALORIC EXPENDITURE
42 STUDENTS' FIVE-DAY RECORDS

Activities Requiring					
150 Cal/hr or less		151-250 Cal/hr		Over 250 Cal/hr	
Sitting	1138	Walking (2 mph)	244	Swimming	72
Sleep, Rest	444	Stairs	31	Basketball playing	59
Personal, Grooming	191	Basketball, light drill	15	Ballroom dance	55
Standing	43	Domestic and miscellaneous moderate activities	9	Fundamentals of movement	53
Walking (2 mph)	40	Ballroom dance, moderate	7	Rhythmic Analysis	26
Light exercise, various types	27			Biking	17
Stairs	16			Miscellaneous strenuous activities	15
				Running	12
Total Calories	1899		306		309

Total Average Daily Expenditure: 2514 Calories

TABLE 3.—AVERAGE DAILY ESTIMATED TIME SPENT
42 STUDENTS' FIVE-DAY SCHOOL RECORDS

Minutes Spent in Activities Classified as					
150 Cal/hr or less		151-250 Cal/hr		Over 250 Cal/hr	
Sitting	690	Walking (2 mph)	85	Swimming	12
Sleep, rest	450	Stairs	9	Fundamentals of Movement	10
Personal	76	Domestic and miscellaneous moderate activity	5	Ballroom Dance	10
Standing	33	Basketball (light drill)	4	Basketball Playing	8
Walking (2 mph)	16	Ballroom dance	2	Rhythmic Analysis	6
Light exercise, various types	10			Biking	4
Stairs	6			Running	2
				Miscellaneous strenuous activity	2
Total minutes	1281		102		54

Total Daily Time: 1440 minutes

TABLE 4.—AVERAGE DAILY ESTIMATED CALORIC EXPENDITURE
38 STUDENTS' ONE-DAY CAMP RECORDS

Activities Requiring					
150 Cal/hr or less		151-250 Cal/hr		Over 250 Cal/hr	
Sitting and Sitting Activities	552	Walking (2 mph)	358	Tennis	123
Sleep, Rest	543	Canoeing (light)	63	Archery, Drawing, Shooting	83
Standing and Standing Activities	247	Games	50	Field Hockey (running)	79
Personal	158	Rowing (light)	37	Biking	66
Walking (2 mph)	76	Recreational and Moderate Domestic Activity	21	Swimming	45
Light Work	8	Diving	11	Canoeing (moderate-strenuous)	39
Stairs	1			Golf	38
				Running	14
				Domestic (strenuous)	10
				Softball (batting, running)	7
Total Calories	1585		540		504

Total Average Daily Expenditure: 2629 Calories

TABLE 5.—AVERAGE DAILY ESTIMATED TIME SPENT
38 STUDENTS' ONE-DAY CAMP RECORDS

Minutes Spent in Activities Classified as					
150 Cal/hr or less		151-250 Cal/hr		Over 250 Cal/hr	
Sleep, rest	552	Walking (2 mph)	125	Tennis	17
Sitting	335	Canoeing (light)	21	Archery, Drawing, Shooting	16
Standing	184	Games	13	Biking	15
Personal	63	Rowing (light)	12	Field Hockey, running	11
Walking (2 mph)	32	Recreational and Moderate Domestic Activity	5	Canoeing (moderate-strenuous)	8
Light work	0.7	Diving	3	Swimming	7
Stairs	4.3			Golf	7
				Running	6
				Domestic (strenuous)	2
				Softball, (batting, running)	1
Total minutes	1171		179		90

Total Daily Time: 1440 minutes

to be lower than usual because of dieting, examinations, or atypical extracurricular activity. The average total energy intake calculated for the group was 2031 ± 455 calories. The estimated caloric intakes were comparable to estimates of food consumption of college women made by others (4, 6, 12).

It was possible to obtain one-day diet and activity records on 38 students during the June camp session. The average daily food intake amounted to 2688 calories. This average intake at camp was approximately 650 calories greater in relation to the average intake found earlier in the school year. The average of the individual estimated expenditures at camp for the 38 students was 2629 calories (Table 4). The average daily time spent in the separate activities is given in Table 5.

Twenty-seven of the students who recorded their diet and activities at camp participated in record keeping earlier in the school year. The caloric intakes and outputs of this smaller group did not differ to any extent from

TABLE 6.—STATISTICAL VALUES FOR COLLEGE FRESHMEN BODY MEASUREMENTS (62 FEMALES, MEAN AGE 18.7 YRS., SD 1.4 YRS.)

Measures	Mean	SD	Percentile				
			5th	25th	50th	75th	95th
Height (in.)	64.4	2.1	60.8	62.9	64	65.9	68.5
Weight (lb.)	135.5	17.4	112.5	123.3	132	145.8	176
Relative weight (%)	108.5	10.8	95	100	107	113	133
Arm circumference (cm.)	27.8	2.2	24.4	26	27.2	29	31.4
Front arm skinfold (mm.)	8.3	3.4	4	6	8	9.5	16
Back arm skinfold (mm.)	17.3	5.5	9	13	16.8	19.8	28
Scapula skinfold (mm.)	14.8	4.9	8	11.3	14	17	25
Abdomen skinfold (mm.)	14.6	5.9	7	10	13.8	17	26

the larger sample. The energy expenditure for this group amounted to 2660 calories; the expenditure at school was 2501 calories. The caloric intake at camp was 2806 calories; at school, the average daily food intake was 2014 total calories.

The body weight and subcutaneous fat measurements were obtained on 62 students. The statistical values are reported in Table 6.

The changes in adipose tissue among the girls who lost weight and those who gained weight between the initial measurement early in the school year and the final measurement at the end of the camp period were tested separately (Table 7). Seventeen of the 49 students for whom these two measurements were available lost weight; 31 gained weight and one showed no change. The students who lost weight showed the expected loss in scapula and abdomen skinfold thicknesses and in upper arm circumference. However, there was a definite tendency toward a gain in the flexor surface arm measurements in this group with a lesser tendency toward increased

TABLE 7.—DIRECTION OF SKINFOLD CHANGES WITH WEIGHT LOSS AND WEIGHT GAIN

	Weight Losers Total = 17			Weight Gainers Total = 31		
Skinfolds	N[a]	X[b]	P ≧ .05[c]	N[a]	X[b]	P ≧ .05[c]
Scapula	15	1(+)	*	27	11(+)	
Abdomen	17	3(+)	*	31	14(−)	
Flexor	16	1(−)	*	29	0(−)	*
Extensor	16	5(−)		29	1(−)	*
Arm Circum.	16	2(+)	*	29	14(−)	

[a] No. of matched pairs which showed difference for measurement.
[b] No. of times the less frequent plus or minus sign occurred.
[c] Significance, one-tailed probability.

TABLE 8.—WEIGHT CHANGES BETWEEN INITIAL SCHOOL, PRECAMP, AND FINAL CAMP MEASUREMENTS

	Initial School to Precamp	Precamp to Final Camp	Initial to Final
	N = 26	N = 26	N = 27
Range of Difference	−9.5 to 7 lb.	−10.5 to 7.25 lb.	−11.75 to 10.5 lb.
Mean Difference	.7 lb.	.4 lb.	1.4 lb.
S. E. of Difference	.7 lb.	.75 lb.	.96 lb.
Paired "t"	.94[a]	.56[a]	1.47[a]

[a] Nonsignificant.

extensor skinfolds. Half of the girls who gained weight had increased arm circumferences, as was also true for the abdomen skinfold thicknesses. The weight gain group showed a tendency toward greater scapula skinfolds and definite change to greater extensor and flexor subcutaneous fat.

A comparison of the weight change for the 27 students between the initial measurement and final camp weight revealed no significant difference (Table 8). There was an average gain of 1.4 lbs. between the two periods. A negligible average weight increase of 0.4 lb. occurred over the four-week camp session and of 0.7 lb. from the initial to precamp weight. A highly significant increase in flexor and extensor skinfolds and a significant decrease in scapula skinfolds were found in this group (Table 9).

Discussion

The amount of time devoted to exercise for the group of students in this study was increased substantially during four weeks at a spring camp at the close of a school year over that performed early in the academic year. It was thought that conditions such as these were ideal for observing what effect increased activity might have on physical fitness, food consumption, weight loss or gain, and subcutaneous fat.

The improved physiological response to a test measuring endurance for sustained effort corresponded well with the progressively increased amount

TABLE 9.—SKINFOLD THICKNESS AND ARM CIRCUMFERENCE CHANGES BETWEEN INITIAL SCHOOL AND FINAL CAMP MEASUREMENTS

	Skinfold Thickness (mm.) N = 27				Upper Arm Circumference (cm.) N = 27
	Scapula	Abdomen	Flexor	Extensor	
Range of Difference	−14 to 3.5	−10 to 6.5	0 to 10.5	−10 to 12	−3.6 to 1.9
Mean Difference	−1.4	−1.2	5.4	2.9	− .10
S. E. of Difference	.68	.62	.48	.86	.24
Paired "t"	2.06[a]	1.82	11.37[b]	3.41[b]	.41

[a] Significant at 5 percent level.
[b] Significant beyond 1 percent level.

of exercise within the year. Actually, the activity data indicated only a very slight increase of caloric output at camp over that at school, a matter of 115 calories daily. Both sets of records were representative of weekday activities. Most probably the apparently high expenditures at school had been due to overestimation of actual time spent in performing physical activities. This may occur when the estimates are made by the subjects themselves (5). At camp, where it was possible to have an observer time class activities and categorize the movements more closely, the students' own records were compared with those of the observer. By this type of comparison overestimates of recorded activities could be detected and corrected.

With an average estimated expenditure of 2660 calories during four weeks of an increased activity program, a group of 27 students were found to consume approximately 2800 calories as food. This balance of caloric output and caloric intake is evidenced in the nonsignificant change in weight for the group over the four weeks (Table 8). The energy intake was nearly 800 calories greater at the spring camp than early in the college year, or when compared with other college groups of the same age (4, 6, 12).

The skinfold thickness areas which reflected weight loss most significantly were the scapular and abdominal sites, respectively. Arm circumference was also a good indicator of this weight change. There was a discrepancy between arm flexor surface skinfolds and even more between extensor surface skinfolds on the one hand and weight gain (or loss) on the other. Although more subjects who gained had an increase in the extensor skinfold measurements than those who lost weight, the tendency for weight losers to gain adipose tissue at this site and at the flexor site cannot be explained readily. Possibly, due to field exercise on a hot day immediately preceding the skinfold measurements at camp, a hyperemia of the upper arm occurred which affected skinfold determinations at these two sites.

Summary and Conclusions

Physical fitness tests, skinfold measurements, estimated activity expenditures, and caloric intakes were obtained on a group of college freshmen

enrolled in a physical education and physical therapy curriculum. The better performance in fitness tests exhibited at the end of the school season demonstrated the increased endurance of the students after an increasingly active year. Weight loss appeared to correlate well with decreased subcutaneous fat at scapular and abdominal sites. However, arm skinfold thicknesses (flexor surface) increased significantly whether the student gained or lost weight; the reason for this finding is not clear. When self-kept activity records were compared with supervised and timed observations, it was clear that they showed a tendency of the student to overestimate actual time spent in performing any given movement. Average daily food intakes increased during a period of rigorous spring physical activity over the ordinary food consumption in the regular school period but the average body weight remained constant.

References

1. Bowes, A. de P. *Food Values of Portions Commonly Used.* Philadelphia: College Offset Press, 1956.
2. Brouha, L., and Gallagher, J. R. "A Simple Method of Testing the Physical Fitness of Boys." *Health and Safety* 8: 1; 1943.
3. Conn, J. W. "Obesity 2. Etiological Aspects." *Physiological Reviews* 24: 31-45; January 1944.
4. Donelson, E. G., and others. "Nutrition Status of Midwestern College Women." *Journal of American Dietetic Association* 21: 145-47; March 1945.
5. Doris, R. J., and Stunkard, A. J. "Physical Activity: Performance and Attitudes of a Group of Obese Women." *American Journal of Medical Science* 233: 622-28; June 1957.
6. Greenwood, M. L., and Lonsinger, B. N. "Food Intake of College Women; Caloric Intake and Energy Requirement." *Journal of American Dietetic Association* 20: 524-27; September 1944.
7. Mayer, J. "The Role of Exercise and Activity in Weight Control." *Weight Control* (A Collection of Papers). Ames, Iowa: Iowa State College Press, 1955.
8. Mayer, J., and others. "Exercise, Food Intake and Body Weight in Normal Rats and Genetically Obese Adult Mice." *American Journal of Physiology* 177: 544-48; June 1954.
9. Mayer, J.; Roy, P.; and Metra, K. P. "Relation Between Caloric Intake, Body Weight, and Physical Work in an Industrial Male Population in West Bengal. *American Journal of Clinical Nutrition* 4: 169-75; March-April 1956.
10. *Medico-Actuarial Mortality Investigations.* Association of Life Insurance Medical Directors and the Actuarial Society of America. Vol. 1. New York, 1912.
11. Passmore, R., and Durnin, J. V. G. A. "Human Energy Expenditure." *Physiological Reviews* 35: 801-40; October 1955.
12. Pittman, M. S., and others. "Caloric Intakes of 27 College Women." *Journal of American Dietetic Association* 18: 449-53; July 1942.
13. Siegel, Sidney. *Nonparametric Statistics.* New York: McGraw-Hill Book Co., Inc. 1952.
14. Watt, B. K., and Merrill, A. L. Composition of Foods. Agricultural Handbook No. 8. Washington, D. C.: U. S. Government Printing Office, 1950.

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Relationship between Grip Strength and Achievement in Physical Education among College Men[1]

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Abstract

Grip strength was compared to physical education achievement grades for 635 college men. The relationship was found to be significant and positive. Grip strength is directly related to and probably dependent upon body weight and only indirectly related to height in college men. A significantly larger proportion of left-handed men have a stronger right grip as compared to right-handed men with a stronger left grip.

YOUNG MEN AND WOMEN who arrive on a university campus with a deficiency in ability to read, communicate, or handle numbers are at a disadvantage in their subsequent college work. This is the basis for screening tests of various kinds administered to college freshmen before or soon after matriculation. It is also generally assumed that improvement services will correct these deficiencies, at least in part, and hence tend to prevent academic failure. But reading, communication arts, and arithmetic have been required subjects in public and private schools for a long time. There is reasonable uniformity in instruction, course content, and achievement standards in these subjects. Nevertheless, many universities consider screening and improvement courses, usually on a noncredit basis, essential. How much more important must a similar appraisal be with regard to physical education where one can make almost no assumptions about the physical fitness, skills, or past experience of entering freshmen.

Of the various characteristics of an individual which contribute to his physical ability, none seems so universally important to performance in sports and other physical activities as does body strength. Muscular strength has been demonstrated to be correlated with general athletic ability (4, 9, 10, 12) and, thus, has utility in equating teams for athletic competition (2). Strength has also been shown to be correlated with frequency of participation in play activities in children (15) and their ability to learn to throw and catch a ball (14). Strength, therefore, may be a factor in achievement in physical education among college men. It may be also postulated that increasing strength may prevent academic failures in physical education. As a preliminary investigation to study the relationship between strength and achievement in physical education among a group of college men, a simple

[1]This study is supplemental to the investigation by Wessel and Nelson in this issue of the RESEARCH QUARTERLY, page 244.

measure, grip strength, was compared with final grades in instructional physical education courses.

Procedure

Michigan State University is operated on a quarter basis, so that the duration of each course (activity) is about three months. Two years (six terms) of physical education are required of all students. During the first eight weeks of one term, grip strength was measured in 635 freshmen and sophomores who were enrolled in one of the following activities: badminton, boxing, beginning swimming, doubles tumbling, foil fencing, ice skating, wrestling, bowling, tap dancing, singles tumbling, handball, individual athletics (track and field), apparatus stunts, group games, and tennis. Classes in these activities were selected at random, and the tests were administered in small groups to all of the men present in class on the testing day. The senior author administered all of the tests. The test using a nonadjustable grip dynamometer, was administered as described by Clarke (3). In addition to grip strength, the following information was recorded on each subject: name, class, date of birth, height, weight, and dominant hand. Time of day varied with the different activity classes tested.

The instructor of a particular activity was never given any of the information reported on the individuals in his class. Shortly after the term came to an end, the physical education grade for each student was obtained. A grading system of A, B, C, D, and F is employed where A is superior and F is a failing grade. The specific grading plan varied to some extent with each course and even between instructors in the same course. However, the plan used as a guide in all courses suggested that 80 percent of the grade be based upon performance, 10 percent on a written examination, and 10 percent on healthmanship and/or sportsmanship.

Results

Inasmuch as the grip strength test was administered twice with each hand, it was possible to study the reproducibility of the test results. The coefficient of reliability for the right hand was 0.80 and for the left hand 0.84. When the better grip with the right hand was correlated with the better grip of the left hand, the obtained coefficient of 0.58 is not surprising since some of the men had a stronger right hand, while in others the left was stronger. When the better grip of the stronger hand was correlated with the better grip of the weaker hand, the coefficient became 0.81. The grip strength score used in the analysis was the sum of the right and left hand using the better score of each hand.

A comparison of the mean grip strength scores for the various letter grade groups (all 12 activities combined) is illustrated on the left side of Figure 1. One hundred and forty-four men received a grade of A, 248 a B, 196 a C, 38 a D and 9 an F. Since there were so few F grades, they were combined with the D's. Analysis of variance produced an F value of 17.50 (probability less than 0.01). When the various means were compared using a large sample

t (critical ratio), all six differences were statistically significant with probabilities less than 0.05. The t's ranged from 2.18 to 4.13.

It was of interest to study the relationship between grip strength and weight, height, and age. All three correlation coefficients were statistically significant, but the r for age was very low (see Table 1). When the influence of height was eliminated the partial correlation between grip strength and weight ($r = 0.34$) remained statistically significant at a probability less than 0.001. On the other hand, when the effect of weight was eliminated, the partial correlation coefficients between grip strength and height becomes insignificant ($P = 0.06$). This indicates that weight is the important variable as related to grip strength, not height.

TABLE 1.—CORRELATION COEFFICIENTS BETWEEN GRIP STRENGTH AND AGE, HEIGHT, AND WEIGHT (N = 635)

	Mean	r	P
Age (yrs.)	19.1	0.118	<0.003
Height (ins.)	70.3	0.326	<0.001
Weight (lbs.)	159.7	0.451	<0.001

It was thought that the relationship between grip strength and achievement in physical education might be refined by considering body weight. Accordingly, the following regression equation for predicting grip strength from body weight was derived from the data.

$$X' = 0.76\ Y + 135.77$$

where X′ is the predicted sum of right and left grip strength in pounds and Y is the body weight in pounds. Each of the 635 grip strength scores was predicted using this equation. A residual score was then derived for each subject by subtracting his predicted from his actual grip strength score, a plus residual indicating above average strength for a given weight and a negative residual indicating the opposite. A comparison of the mean residual scores for the various letter grade groups is illustrated on the right side of Figure I. Analysis of variance resulted in an F value of 5.41 (probability less than 0.01). The t's ranged from 1.84 to 6.66. With the exception of the comparison of the mean residual scores for the B and C groups, the differences were all statistically significant at a probability less than 0.05. In the exception, the probability was 0.06. The F value and t's in the comparison of the residual scores were no larger than when the crude grip strength scores were used. Hence, the use of the body weight regression equation hardly seems justified.

Five hundred and three of the subjects stated that they were definitely right handed. Of these, 51 or 10.1 percent had stronger left hands. Of the 47 who declared themselves to be left-handed, 21 or 44.7 percent had stronger right hands. A chi square of 35.7 (probability, less than 0.001) indicates that it is not reasonable to attribute the differences in percentages to chance.

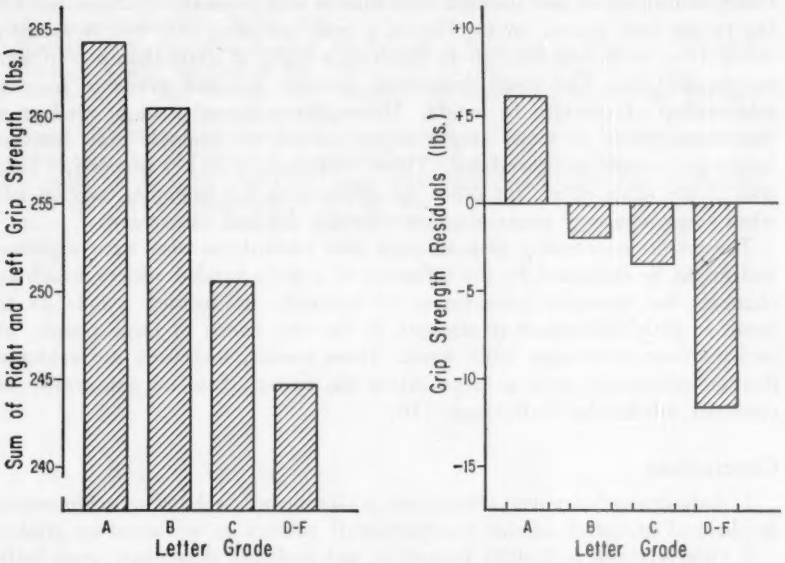

FIGURE I. Relationship Between Achievement in Physical Education and Grip Strength and Grip Strength Residual.

Discussion

It must be recognized that grip strength is hardly a satisfactory measure of total strength, although the relationship is reasonably good (1, 3, 11, 13). Furthermore, reproducability of the test is only fair. The reliability obtained is about what others have secured (1, 5). Limitations of grading plans are also well known. There are differences between activities and between instructors teaching the same activity. A portion of the grade is frequently not based upon achievement in skills in the activity. Finally, strength might be expected to correlate more closely to some physical education activities than others, but in the present study, subjects from all courses were combined. Despite all these limitations, the simple test of grip strength differentiates between the letter grade groups. Reducing these vitiating influences would no doubt make it possible to differentiate more clearly between the groups. The fact that correlation between achievement grade and grip strength in college men has been demonstrated is not proof that increasing strength will result in higher grades. This remains to be demonstrated by further research.

The interrelationship between weight and strength in college men is not new (8). The correlation coefficient of 0.451 is about what others have obtained: $r = 0.321$ (4, p. 382), $r = 0.40$ (7). With a greater age range, the coefficient is higher (6). It is also logical that the fundamental correlation is between strength and weight and not between strength and height.

Other factors equal, the strength of a muscle will generally increase according to the load placed on it. Hence, a man weighing 200 lbs. is actually doing more work with his legs in climbing a flight of stairs than a man who weighs 150 lbs. The same theoretical grounds are not available for the relationship of strength to height. Hence, from a statistical as well as a theoretical point of view, height seems related to strength only because height and weight are correlated. These relationships do not necessarily hold true to the same extent for other age groups, as for example, later in life when some men may accumulate considerable fat and others not.

The results concerning grip strength and handedness also were expected and might be explained by the influence of a right-handed society which so channels the muscular experiences of naturally left-handed people as to result in little differences in strength in the two hands of these people, or perhaps even a stronger right hand. These results, therefore, are evidence that ambidexterity is to a large extent the result of social conformity of naturally left-handed individuals (16).

Conclusions

1. Grip strength among college men is significantly related to achievement in physical education service (instructional) courses as measured by grades.
2. Grip strength is directly related to and probably dependent upon body weight and only indirectly related to height in college men.
3. A significantly larger proportion of left-handed men have a stronger right grip as compared to right-handed men with a stronger left grip.

References

1. Brown, H. S. "A Comparative Study of Motor Fitness Tests." *Research Quarterly* 25: 8-19; 1959.
2. Clarke, H. H., and Bonesteel, H. A. "Equalizing the Abilities of Intramural Teams in a Small High School." *Suppl. to Research Quarterly* 6: 27; 1935.
3. Clarke, H. H. *Application of Measurement to Health and Physical Education.* Third edition; Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1959.
4. Cureton, T. K. *Physical Fitness Appraisal and Guidance.* St. Louis: The C. V. Mosby Co., 1947.
5. DiGiovanna, V. "The Relationship of Selected Structural and Functional Measures to Success in College Athletics." *Research Quarterly* 14: 199-216; 1943.
6. Everett, P. V., and Sills, F. D. "The Relationship of Grip Strength to Stature, Somatotype Components, and Anthropometric Measurements of the Hand." *Research Quarterly* 23: 161-66; 1952.
7. Gates, A. I. "The Nature and Significance of Physical Status and of Mental, Physiological, Social, and Emotional Maturity." *Journal of Educational Psychology.* 15: 1924.
8. Hunsicker, P., and Greey, G. "Studies in Human Strength." *Research Quarterly* 28: 109-22; 1957.
9. Larson, L. A., and Yocom, R. D. *Measurement and Evaluation in Physical Health and Recreation Education.* St. Louis: The C. V. Mosby Co., 1951.
10. McCloy, C. H., and Young, N. D. *Tests and Measurements in Health and Physical Education.* Third edition. New York: Appleton-Century-Crofts, Inc., 1954.

11. PHILLIPS, M. "Study of a Series of Physical Education Tests by Factor Analysis." *Research Quarterly* 20: 60-71; 1949.
12. ROGERS, F. R. *The Fundamental Administrative Measures in Physical Education.* Newton, Mass.: The Pleiades Co., 1937.
13. SCOTT, M. G., and WILSON, M. "Physical Efficiency Tests for College Women." *Research Quarterly* 19: 62-69; 1948.
14. SMITH, J. "Relation of Certain Physical Traits and Abilities to Motor Learning in Elementary School Children." *Research Quarterly* 27: 220-28; 1956.
15. VAN DALEN, D. B. "A Study of Certain Factors in their Relation to the Play of Children." *Research Quarterly* 18: 279-90; 1947.
16. WITE, I. S. *Handedness: Right and Left.* Boston: Lothrop, Lee and Shepard Co., 1934.

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Relationship between Grip Strength and Achievement in Physical Education among College Women

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Abstract

The purpose of this study was twofold: (1) to investigate the relationship between strength and achievement in physical education among 200 college women by comparing grip strength with grades in the instructional physical education courses and (2) to compare the results obtained on college women with those of college men in the study by Tinkle and Montoye reported in this issue of the *Research Quarterly*. A table of random numbers was used to secure the sample. The results indicated that grip strength among college women was significantly related to achievement in physical education instructional courses as measured by grades. Also, grip strength was found to be directly related to and probably dependent upon body weight and only indirectly related to height in college women. The relationship between grades in physical education and grip strength among college women substantiates the results of the college men's study.

THIS STUDY IS supplemental to the investigation reported by Tinkle and Montoye in this issue of the *Research Quarterly*. The review of the literature of the relationship of strength to physical performance is included in their study, which begins on page 238.

Procedure

Two years (six terms) of physical education are required of all women students at Michigan State University. A random selection of college women enrolled in the two-year required program of physical education at Michigan State University was secured by using a table of random numbers. These women agreed to serve as subjects. The physical education courses with the number and percent of students who had enrolled in each course are presented in Table 1. During the first four weeks of spring term, grip strength was measured by using a nonadjustable grip dynamometer. The test was administered by instructors in the Department of Health, Physical Education, and Recreation. In addition to grip strength, the following information was recorded on each subject: name, class, date of birth, height, weight, and all physical education courses taken with corresponding grades. The grading system of A, B, C, D, and F is employed where A is superior and F is a failing grade. Each letter grade was assigned a point value. The point value ranged from four points for an A to zero points for an F. The total points

TABLE 1.—MEAN GRIP STRENGTH SCORES FOR SUBJECTS ENROLLED IN SPECIFIC PHYSICAL EDUCATION COURSES

Physical Education Course	Number	Mean Grip Strength Scores
Dance[a]	135	144.28
Bowling	112	142.06
Swimming and Diving[b]	66	142.97
Tennis	66	145.67
Gymnastics and Tumbling	64	142.97
Ice Skating[c]	61	141.43
Fencing	42	136.95
Basketball	24	157.50
Softball	18	161.28
Volleyball	22	162.77
Archery	21	139.67
Badminton	13	153.54
Hockey	8	160.50
Golf	7	130.43
LaCrosse	2	158.00

[a] Dance included social, folk, tap, square and contemporary courses.
[b] Swimming included beginning, intermediate, advanced, life saving and diving courses.
[c] Ice Skating included beginning, intermediate and advanced courses.

for all the instructional physical education courses taken by each subject were added and the average point value computed. The average point value was used to represent each subject's over-all letter grade in all instructional physical education courses. The average point value scale used to represent the final letter grade is presented below:

Letter Grade Assigned	Point Scale Value
A	3.5—4.0
B	2.9—3.4
C	2.3—2.8
D and F	1.7—2.2

The D and F grades were combined because there were so few F grades.

Results

The means and standard deviations for each variable used in this study are presented in Table 2. The coefficients of objectivity were secured for

TABLE 2.—MEANS AND STANDARD DEVIATION OF AGE, HEIGHT, WEIGHT, GRIP STRENGTH, AND GRADES IN PHYSICAL EDUCATION COURSES

Variable	Mean	Standard Deviation
Age (years)	19.30	0.84
Height (inches)	64.14	2.48
Weight (pounds)	125.56	16.23
Left grip (dynamometer)	68.85	11.72
Right grip (dynamometer)	75.32	12.62
Physical Education Grades	2.90	0.56

grip strength by retesting 60 students with different scores one week after the initial test period. The coefficient of objectivity for the right hand was 0.81 and for the left hand 0.83. The grip strength score used in the analysis was the sum of the right and left hand using the better score of each hand.

A comparison of the mean grip strength scores for the various letter grades (all courses combined) is illustrated on the left side of Figure I. Analysis of variance produced an F value of 6.22 (probability less than 0.01). The comparison of the various means using a large sample t (critical ratio) is

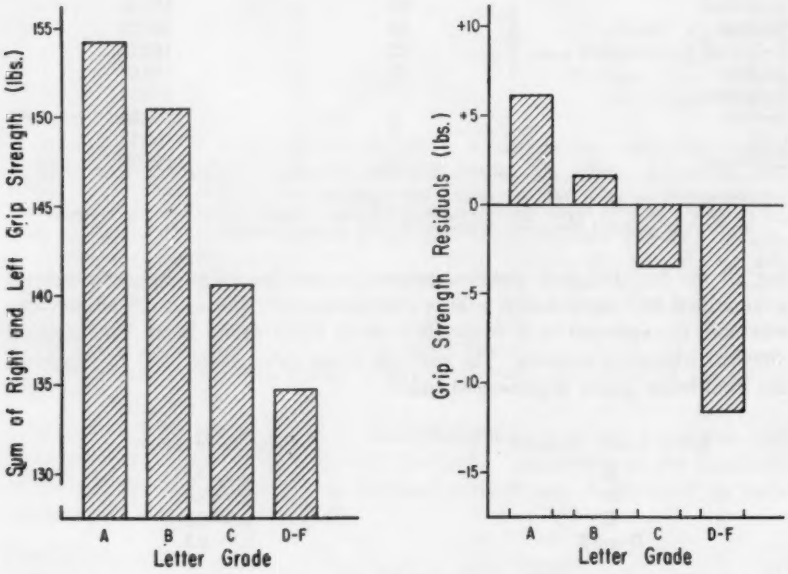

FIGURE I. Relationship Between Achievement in Physical Education and Grip Strength and Grip Strength Residual.

presented in Table 3. Four differences were found to be statistically significant with probabilities less than 0.02; and, two differences (A vs. B and C vs. D) were not significant. It was of interest to find that the two insignificant differences were between adjacent grades (A vs. B and C vs. D). The significant difference between B vs. C was the most meaningful one of the four significant differences (A vs. C, A vs. D, B vs. C, and B vs. D). In the college men's study all differences were found to be significant with probabilities less than 0.05.

It was of interest to study the relationship between grip strength and weight and height for college women and to compare these findings with the results of the college men's study. All correlation coefficients were statistically significant for women. The correlation between grip strength

and weight was $r = 0.371$, at a probability less than 0.01; and grip strength and height was $r = 0.222$, at a probability less than 0.01. When the influence of height was eliminated the partial correlation between grip strength and weight remained statistically significant at a probability less than 0.01. On the other hand when the effect of weight was eliminated, the partial correlation coefficient between grip strength and height becomes insignificant. These findings were similar to the results found in the college men's study.

The following regression equation for predicting grip strength from body weight was derived from the data

$$X' = 0.52\,Y + 78.59$$

X′ is the predicted sum of right and left grip strength in pounds and Y is the body weight in pounds. Each of the grip strength scores was predicted using this equation. A residual score was then derived for each subject by subtracting her predicted from her actual grip strength score, a plus residual indicating above average strength for a given weight and a negative residual indicating a below average strength for a given weight. A comparison of the mean residual scores for the various letter grade groups is illustrated in the right side of Figure I. The comparison of the various means using the large sample t (critical ratio) is shown in Table 4.

TABLE 3.—t-RATIOS FOR THE COMPARISON OF MEAN GRIP STRENGTH AMONG VARIOUS LETTER GRADE GROUPS

Letter Grade Comparison	t	Degrees of Freedom	Probability
A vs. B	0.692	104	not significant
A vs. C	2.96	102	<.01
A vs. D	3.56	65	<.01
B vs. C	2.59	126	<.02
B vs. D	3.16	89	<.01
C vs. D	1.09	87	not significant

TABLE 4.—t-RATIOS FOR THE COMPARISON OF MEAN GRIP STRENGTH RESIDUALS AMONG VARIOUS LETTER GRADE GROUPS

Letter Grade Comparison	t	Degrees of Freedom	Probability
A vs. B	1.469	104	not significant
A vs. C	3.097	102	0.01
A vs. D	4.135	65	0.01
B vs. C	1.994	126	0.05
B vs. D	3.166	89	0.01
C vs. D	1.419	87	not significant

Discussion

There were certain limitations involved in this study, similar to those discussed in the college men's study, namely, limitations of the grading plans, reproducibility of the test, relationship of grip strength to a measure of total

strength, and the fact that strength probably correlates more closely with some physical education courses than others. Limitations specific to this study include the method of arriving at a final letter grade combining subjects from all courses taken previously to the test period. However, with all these limitations, the simple test of grip strength was found to differentiate between letter grade groups among college women as well as for college men. The differentiation was nonexistent for college women between adjacent grades A vs. B and C vs. D. The significant difference between B vs. C was the most meaningful one of the four significant differences for college women. These differences may be accounted for by the difference in the size of the sample as well as a difference in grading between men and women instructors.

The fact that the correlation between grades in physical education and grip strength in college women substantiates the results of the college men's study is still not proof that increasing strength will result in higher grades. Perhaps there is a causal relationship in the fact that those students who have been more active are stronger, better skilled, and are more interested in achieving a higher level of competency. It would seem, however, that a certain degree of strength is needed for a better chance to achieve success in physical activities. Such proof remains to be demonstrated by further research.

The interrelationship between weight and strength in college women was similar to the findings reported in the study with college men. The correlation coefficient of 0.451 for men was higher than the correlation coefficient of 0.371 for women. However, when the influence of height was eliminated the partial correlation between grip strength and weight for men was $r = 0.34$ and for women $r = 0.32$, both significant at probability less than 0.01. These results would seem to bear out the logic that the fundamental correlation is between strength and weight and not between strength and height for both sexes. Hence height seemed to be related to the strength because height and weight were correlated. As handedness was not indicated in the college women's study, no comparisons were made.

Conclusions

1. Grip strength among college women was significantly related to achievement in physical education instructional courses as measured by grades.
2. Grip strength was directly related to and probably dependent upon body weight and only indirectly related to height in college women.
3. The fact that the correlation between grades in physical education and grip strength in college women substantiates the results of the college men's study is still not proof that increasing strength will result in higher grades.
4. The relationship between grades in physical education and grip strength among college women substantiates the results of the college men's study reported by Tinkle and Montoye.

(Submitted 6/27/60)

Effects of Elementary School Physical Education upon Aspects of Physical, Motor, and Personality Development[1]

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Abstract

This article presents the results of a study of two groups of 81 12-year-old boys who were comparable in such maturity factors as chronological age, skeletal age, weight, height, and Wetzel developmental level. The group in the good physical education program had participated for at least three years; the group in the poor program had little or no physical education in elementary school. There were pronounced differences found between the two groups. The boys in the good program surpassed the boys in the poor program in Rogers Physical Fitness Index (PFI), Metheny-Johnson Test of Motor Educability, the Indiana Motor Fitness Test, and the Vertical Jump. A further investigation was completed in this study. Boys in each group who participated a lot in out-of-class physical activity showed strong superiority over those who participated a little in out-of-class physical activity.

THE PRIMARY PURPOSE of this study was to determine the effects of elementary school physical education upon certain aspects of physical development, motor fitness, motor educability, body flexibility, muscular explosive power, and the personality of 12-year-old boys. In this process, a contrast was made for the elements studied between boys who had participated in good and poor elementary school physical education programs. In addition, the same characteristics were studied for boys in each category, good and poor elementary school physical education programs, who participated a lot and a little in physical education activities outside physical education classes.

In realizing the purposes of this study, two factors were investigated. These factors with their related elements are:

1. Maturity elements: chronological age, skeletal age, height, weight, and growth level.
2. Affective elements: basic strength, motor fitness, motor educability, body flexibility, muscular explosive power, and personality.

The maturity factors were selected as elements which would reveal the basic growth and development of boys. It was believed that these elements would not be affected significantly by physical education participation. Thus, it is primarily with the affective elements that any values of elementary school physical education revealed in this study would be demonstrated.

[1] Acknowledgment is extended to H. Harrison Clarke, research professor at the University of Oregon, under whose guidance this study was completed.

Test Items

MATURITY ELEMENTS

Chronological Age. Boys were 12 years of age ± 6.5 months as of the testing day, specified as between 11 years, 5 months and 16 days, and 12 years, 6 months and 15 days.

Skeletal Age. The X-ray technique advocated by Bayer and Bayley was followed. The Greulich-Pyle technique was used for the assessment of the carpal area.

Height. Height was recorded to the nearest half inch.

Weight. Weight to the nearest half pound was recorded. The measures of height and weight were made with boys attired in light underclothing and stocking feet.

Growth Level. Since the measures of height and weight were already recorded, the plotting of the developmental level on the Wetzel Grid was a relatively easy task.

McCloy's Classification Index I. Age, height, and weight were used in McCloy's Classification Index I.

AFFECTIVE TEST BATTERIES

The following affective test batteries were employed in this study: Rogers Strength Index; Rogers Physical Fitness Index; Indiana Physical Fitness Test for the Elementary Level; Metheny-Johnson Test of Motor Educability; California Test of Personality.

AFFECTIVE TEST ITEMS

Six test items from the test batteries plus three measures of flexibility were examined in the study. These were: vertical jump; arm strength (combined push-ups and pull-ups in Rogers' formula); leg lift; back lift; lung capacity; and trunk, hip, and ankle flexibility. Flexibility was measured by means of the Leighton Flexometer.

Research Procedures

Selection of Schools. Fourteen schools in Lane County and two in Multnomah County in the State of Oregon were visited. These schools were evaluated by means of a 12-item modified form of Laporte's Elementary School Score Card. On the basis of points scored on this card, four schools were classified as having a good physical education program, and five schools were found to have a poor physical education program. Hereafter, in this report, these schools will be known as good and poor as related to their respective physical education programs. For the good schools, the points on the modified score card varied from 40 to 48 out of a possible 60, with a median of 42; while for the poor schools the scores ranged from 18 to 26 with a median of 23. The difference between the medians was 19 rating points.

Activity Questionnaire. In order to assess the amount of physical activity in which a boy participated, an activity questionnaire was devised. The questionnaire was arranged on the assumption that boys participated in the

following three types of physical activity besides the regular physical education classes at the school: extramural teams organized by the school, out-of-school organized teams or clubs, and regular playground activities without emphasis on team practices or competitive games.

The terms *lot* and *little* were used in the comparative analysis of this study. Lot applies to a boy who was a member of at least three organized athletic teams and participated in at least three playground activities. *Little* indicates a boy who was not a regular member of more than one (or a substitute member of more than two) organized athletic teams and who did not participate in more than two different kinds of playground sports. Roughly, these designations identified with 25 percent most active and the 25 percent least active boys participating in out-of-class physical activities.

Selection of Subjects. The bases for selecting the actual boys to participate in the study were as follows:

Each boy must have been enrolled in his school for the preceding three years, so as to ensure participation in the same type of physical education program for this length of time. The chronological age of each boy at the time of testing must have been 12 years plus or minus 6.5 months. Wetzel Grid classifications in channels between A3 and B3 inclusive were required. No boys with physical abnormalities were admitted to the study.

A further limitation may have been placed on the sample as each boy was required to have his parents' permission to leave the school for some of the tests. Hence, only boys who were actually willing to be tested were included.

The total number of boys satisfying the above criteria was 162; 81 were from schools in the good classification and 81 in the poor classification.

Test Administration. A pretest period was organized by using a group of 25 elementary grade students age 12 years. A number of the difficulties encountered in the conduct of the tests were corrected during this training period.

All measurements were taken by the investigator assisted by trained graduate students, selected because of previous experience in testing. Strict supervision of the testing procedure was in practice throughout each period of the tests. Every possible effort was made to get the best effort from each boy on every measurement. The identity of all schools and their physical education classifications were kept from the testers before and during the administration of all tests.

Two test periods were organized. Testing Period A was scheduled a day in advance of Testing Period B. All measurements were taken in the afternoon hours from 1 to 4 p.m. during the month of May 1955. The following tests were given during Test Period A: three items of the Indiana Physical Fitness test, California Test of Personality, three measures of flexibility, and the activity questionnaire. During Test Period B the following were administered: Rogers Physical Fitness Index battery, vertical jump, Metheny-Johnson Test of Motor Educability, and wrist-hand X ray.

Analyses. In analysing the data obtained in this study, several comparisons were utilized in order to separate clearly the various phases of the problem. These were as follows.

1. A comparison was made between the 81 boys who had participated in each of the good and poor elementary school physical education programs with the age range 12 ± 6 months.

2. Inasmuch as a number of earlier growth studies of Oregon boys had been made limiting the age range to two months from the birthday, a further comparison was made on this basis, 12 years ± 2 months. In this group there were 38 boys in the good program and 37 in the poor program.

3. Additional comparisons are presented for all boys (12 years ± 6 months) who participated a lot and a little in physical activities outside the school physical education classes for both the good and the poor program. There are four distinct groupings in this category, characterized as follows: lot-good (N = 20); lot-poor (N = 15); little-good (N = 24); and little-poor (N = 29).

4. The means on all tests and test items were computed separately for all categories identified. In some instances standard deviations were also computed. The basic statistical procedure was to compare these measures. In interpreting the significance between the means and standard deviations, t values were computed and significance was established at the .05 and .01 levels of confidence.

TABLE 1.—COMPARISON OF THE MEANS OF THE MATURITY ELEMENTS IN THE GOOD AND POOR PHYSICAL EDUCATION PROGRAMS

Age 12 ± 6 Months				
Element	Mean Good (N = 81)	Mean Poor (N = 81)	Diff. between Means	t
Age (Chronological)	12.06	12.04	.02	.50
Age (Skeletal)	12.22	12.14	.08	.16
Height	59.06	58.98	.08	.19
Weight	89.65	90.60	.95	.41
Developmental Level (Wetzel Grid)	116.45	116.57	.12	.05
Classification Index (McCloy's Index I)	683.91	684.77	.86	.18

Age 12 ± 2 Months				
Element	Mean Good (N = 38)	Mean Poor (N = 37)	Diff. between Means	t
Age (Chronological)	12.03	12.02	.01	.33
Age (Skeletal)	12.19	12.30	.11	.61
Height	59.21	59.54	.33	.58
Weight	89.50	92.27	2.77	.83
Developmental Level	117.26	118.76	1.50	.44
Classification Index	685.72	689.81	4.09	.65

Summary of Results

(Age 12 years ± 6 months and 12 ± 2 months).

MATURITY ELEMENTS

A marked similarity in typical performance was found in all basic growth elements included in this study; chronological age, skeletal age, height, weight, Wetzel developmental level, and McCloy's classification Index I, between the groups at both age levels, 12 years ± 6 months, and 12 years ± 2 months. The highest t, as shown in Table 1, was .83 for weight, a t which is still far below acceptable confidence levels.

AFFECTIVE TEST BATTERIES AND TEST ELEMENTS

The following statements summarize the major findings from this study. Each of the statements was valid at the .05 level of confidence or better.

1. The mean PFI for the boys in the good physical education program was 120.79; in the poor physical education program, 103.02. Compared with

TABLE 2.—COMPARISON OF THE MEANS OF THE AFFECTIVE TEST BATTERIES IN THE GOOD AND POOR PHYSICAL EDUCATION PROGRAMS

Age 12 ± 6 Months				
Test	Mean Good (N = 81)	Mean Poor (N = 81)	Diff. between Means	t
Rogers' Physical Fitness Index	120.79	103.02	17.77	5.64*
Rogers' Strength Index	1202.18	1032.45	169.76	4.97*
Metheny-Johnson Test of Motor Educability	23.72	19.75	3.97	5.09*
Indiana Physical Fitness Test	392.92	324.40	68.52	2.59*
California Test of Personality	105.52	108.92	3.40	1.28

Age 12 ± 2 Months				
Test	Mean Good (N = 38)	Mean Poor (N = 37)	Diff. between Means	t
Rogers' Physical Fitness Index	118.19	103.69	14.50	3.07*
Rogers' Strength Index	1182.30	1051. 63	130.68	2.98*
Metheny-Johnson Test of Motor Educability	22.72	20.53	2.19	1.75*
Indiana Physical Fitness Test	384.93	329.81	55.12	1.55
California Test of Personality	106.74	108.08	1.34	.36

* Significant at 5 percent level of confidence.

national standards, the mean of 120.79 for the good group is exceptionally high, exceeding by nearly six points the third quartile of 115.

2. The subjects in the good physical education program were superior on Rogers' Strength Index (SI) to the group in the poor physical education program. The mean difference between these two groups was 169.73 points.

3. The subjects in the good physical education program again demonstrated superior performances to those in the poor program on the Metheny-Johnson Test of Motor Educability.

4. For the Indiana Physical Fitness Test, statistically significant mean differences were found between the good and poor programs for age 12 years ± 6 months but not for age 12 years ± 2 months. However, the good program produced the greater mean in both instances.

5. The analyses of the affective test items outlined in Table 3 for the subjects participating in the good and poor physical education programs for chronological age, 12 years ± 6 months and 12 years ± 2 months reveal that the subjects in the good programs exceeded those in the poor programs in all items except lung capacity. The differences between the means for age 12 years ± 6 months were: leg lift strength, 136.43 lbs.; back lift strength, 25.67 lbs.; vertical jump, .88 in.; and arm strength, 12.48 lbs. For age 12

TABLE 3.—COMPARISON OF THE MEANS OF NINE AFFECTIVE TEST ITEMS IN THE GOOD AND POOR PHYSICAL EDUCATION PROGRAMS

Age 12 ± 6 Months				
Item	Mean Good (N = 81)	Mean Poor (N = 81)	Diff. between Means	t
Vertical Jump	12.62	11.74	.88	2.51[a]
Grip Strength	107.61	102.91	4.70	1.53
Leg Lift Strength	643.85	507.42	136.43	5.65[a]
Back Lift Strength	249.89	224.22	25.67	4.26[a]
Arm Strength	50.71	38.23	12.48	1.94[a]
Lung Capacity	158.48	158.85	.37	.11
Trunk Flexibility	58.85	55.04	3.81	1.40
Hip Flexibility	118.73	117.68	1.05	.39
Ankle Flexibility	66.37	64.70	1.67	1.31

Age 12 ± 2 Months				
Item	Mean Good (N = 38)	Mean Poor (N = 37)	Diff. between Means	t
Vertical Jump	12.40	11.14	1.26	2.52[a]
Grip Strength	105.72	104.94	.77	.21
Leg Lift Strength	645.46	532.30	113.16	3.39[a]
Back Lift Strength	244.19	225.08	19.11	2.26[a]
Arm Strength	48.56	35.40	13.16	1.47
Lung Capacity	156.21	166.19	9.98	2.28[a]
Trunk Flexibility	56.61	55.78	.82	.21
Hip Flexibility	119.50	118.22	1.78	.42
Ankle Flexibility	66.16	65.68	.48	.28

[a] Significant at 5 percent level of confidence.

years ± 2 months these were: leg lift strength, 113.16 lbs.; vertical jump, 1.26 in.; and back lift strength, 19.11 lbs.

Participation in Out-of-School Physical Activity

Maturity Elements. In the analysis of the participation of the subjects in extraclass physical activity there were some significant differences between means, as shown in Table 4.

TABLE 4.—COMPARISON OF THE MEANS OF THE MATURITY ELEMENTS FOR LOT AND LITTLE PARTICIPATION IN OUT-OF-SCHOOL ACTIVITY.

Maturity Elements	Means					
	Lot Good (24)	Little Good (20)	Lot Poor (15)	Little Poor (29)	Diff.	t
Age (Chronological)	12.02	12.07			.05	.63
			11.99	12.01	.02	.25
	1202			12.01	.01	.14
		12.07	11.99		.08	.89
	12.02		11.99		.03	.33
		12.07		12.01	.06	1.00
Age (Skeletal)	12.28	12.21			.07	.29
			12.46	12.01	.45	1.73[a]
	12.28			12.01	.27	1.17
		12.21	12.46		.25	.93
	12.28		12.46		.18	.70
		12.21		12.01	.20	.83
Height	57.40	59.00			1.60	2.16[a]
			60.40	57.99	2.45	2.58[a]
	57.40			57.99	.59	.84
		59.00	60.40		1.04	1.07
	57.40		60.40		3.00	3.09[a]
		59.00		57.99	1.01	1.40
Weight	87.65	92.70			5.05	6.56[a]
			93.33	87.19	6.14	5.03[a]
	87.65			87.19	.46	.53
		92.70	93.33		.63	.54
	87.65		93.33		5.68	4.69[a]
		92.70		87.19	5.51	2.16[a]
Developmental Level (Wetzel Grid)	114.69	118.15			3.46	.85
			122.73	112.23	10.50	1.67[a]
	114.69			112.23	2.46	.53
		118.15	122.73		4.58	.78
	114.69		122.73		8.04	1.31
		118.15		112.23	5.92	1.40
Classification Index McCloy's Index I	677.73	686.90			9.17	1.20
			698.40	675.43	22.97	1.96[a]
	677.73			675.43	2.30	.27
		686.90	698.40		11.50	1.03
	677.73		698.40		20.67	1.77[a]
		686.90		675.43	11.47	1.49

[a] Significant at 5 percent level of confidence.

1. The lot-poor category was older (skeletally) by .45 months, taller by 2.41 in., heavier by 6.14 lbs., and had a higher Wetzel developmental level by 10.50 lines than the little-poor group. This classification was also taller (3 in.) and heavier (5.68 lbs.) than the lot-good group and had a higher classification index than did the boys in the little-poor and the lot-good categories.

2. The boys in the little-good category were heavier than those in the lot-good (5.05 lbs.) and little-poor (5.51 lbs.) classification and were taller by 1.6 in. than those in the lot-good group.

Affective Test Batteries. Results were as follows.

1. A very high Physical Fitness Index mean of 132.40 was found for the boys in the good program who participated a lot in outside physical ac-

TABLE 5.—COMPARISON OF THE AFFECTIVE TEST BATTERIES FOR LOT AND LITTLE PARTICIPATION IN OUT-OF-SCHOOL ACTIVITY

Test	Means				Diff.	t
	Lot Good (24)	Little Good (20)	Lot Poor (15)	Little Poor (29)		
Rogers Physical Fitness Index	132.40	108.90			23.50	4.65[a]
			116.07	99.99	16.08	3.02[a]
	132.40			99.99	32.41	6.52[a]
		108.90	116.07		7.17	1.33
	132.40		116.07		16.33	2.99[a]
		108.90		99.99	8.91	1.82[a]
Rogers Strength Index	1297.32	1096.90			200.42	4.38[a]
			1217.74	946.81	270.93	4.07[a]
	1297.32			946.81	350.51	7.73[a]
		1096.90	1217.74		120.84	1.81[a]
	1297.32		1217.74		79.58	1.19
		1096.90		946.81	150.09	3.34[a]
Metheny-Johnson Test of Motor Educability	25.40	21.90			3.50	2.20[a]
			21.93	18.71	3.22	2.00[a]
	25.40			18.71	6.69	4.37[a]
		21.90	21.93		.03	.02
	25.40		21.93		3.47	2.07[a]
		21.90		18.71	3.19	2.10[a]
Indiana Physical Fitness Test	428.57	339.40			89.17	1.69[a]
			457.74	281.30	176.44	3.70[a]
	428.57			281.30	147.27	2.91[a]
		339.40	457.74		118.34	2.37[a]
	428.57		457.74		29.17	.47
		339.40		281.30	58.10	1.66[a]
California Test of Personality	105.32	105.19			.13	.03
			115.07	105.33	9.74	2.27[a]
	105.32			105.33	.01	.00
		105.19	115.07		9.88	2.30[a]
	105.32		115.07		9.75	2.17[a]
		105.19		105.33	.14	.03

[a] Significant at 5 percent level of confidence.

tivity; for the lot-poor group, the mean was 116.07. These means are exceptionally high as compared with the national norm of 100 and the national third quartile of 115. Of the various comparisons made, significant differences between mean PFI's were found in all but one instance, the lot-poor vs. little-good mean difference.

2. The subjects in the good physical education programs, with one exception, had a greater Strength Index than the boys in the poor program. The exception was for the lot-poor vs. little-good categories. The Strength Index for the groups ranged from 1297 points for the lot-good category to 947 points for the little-poor group. The highest significant difference was for the lot-good vs. little-poor category with a mean difference of 350.51 points.

3. With one exception, statistically significant mean differences were found for the boys who participated in a lot of outside activity when compared with the group who participated in a little activity on the Metheny-Johnson Test of Motor Educability. The exception was a lot-poor vs. a little-good.

4. The Indiana Physical Fitness Test for Elementary Grades showed the lot of outside activity participants superior to those who participated a little in extra-class activity. In each case there was a statistically significant mean difference.

5. In social and self-adjustment, as measured by the California Test of Personality, the only statistically significant differences were between the lot-poor and little-good classification, the lot-poor and the little-poor group, and the lot-poor and lot-good category. These were in favor of the lot-poor group in all three categories. Early maturation on the part of the lot-poor group as indicated by skeletal age may, in part, account for the higher adjustment scores.

The findings of this study with respect to personality do not bear out results of other investigators. The writer feels that some other factors such as maturation, type of test used, or the school environment may have an influence on the results.

Affective Test Items. Results were as follows.

1. The vertical jump test for explosive muscular power was shown to have statistically mean differences between all groups analyzed, except for boys in the lot-good vs. lot-poor; and the little-good vs. little-poor categories. The highest mean difference of 1.77 inches was recorded between the lot-good vs. little-poor groups.

2. Three categories showed statistically significant mean differences for grip strength. The significant differences between the means were: lot-poor vs. little-poor, 20.03 lbs.; lot-good vs. little-poor, 12.05 lbs.; and lot-poor vs. little-good, 12.92 lbs.

3. In leg lift strength the subjects in the good program showed greater means than those in the poor program by statistically significant margins for all groups except two comparisons. These were in the lot category where,

TABLE 6.—COMPARISON OF THE MEANS OF THE NINE AFFECTIVE TEST ITEMS FOR LOT AND LITTLE PARTICIPATION IN OUT-OF-SCHOOL ACTIVITY

Item	Means				Diff.	t
	Lot Good (24)	Little Good (20)	Lot Poor (15)	Little Poor (29)		
Vertical Jump	13.80	12.28			1.52	3.30[a]
			13.21	12.03	1.18	2.15[a]
	13.80			12.03	1.77	3.40[a]
		12.28	13.21		.93	1.90[a]
	13.80		13.21		.59	1.05
		12.28		12.03	.25	.56
Grip Strength (Left and Right)	108.44	104.15			4.29	.89
			117.07	96.39	20.68	3.15[a]
	108.44			96.39	12.05	2.30[a]
		104.15	117.07		12.92	2.07[a]
	108.44		117.07		8.63	1.32
		104.15		96.39	7.76	1.61
Leg Lift Strength	699.00	571.90			127.10	3.51[a]
			637.73	459.74	177.99	3.95[a]
	699.00			459.74	239.26	7.92[a]
		571.90	637.73		65.83	1.34
	699.00		637.73		61.27	1.34
		571.90		459.74	112.16	3.19[a]
Back Lift Strength	266.90	237.90			29.00	3.33[a]
			247.07	214.40	32.67	2.35[a]
	266.90			214.40	52.50	5.67[a]
		237.90	247.07		9.17	.67
	266.90		247.07		19.83	1.39
		237.90		214.40	23.50	2.80[a]
Arm Strength	72.22	29.40			42.82	3.41[a]
			63.73	31.65	32.08	3.10[a]
	72.22			31.65	40.57	3.42[a]
		29.40	63.73		34.33	3.09[a]
	72.22		63.73		8.49	.67
		29.40		31.65	2.25	.22
Lung Capacity	159.90	152.40			7.50	1.13
			171.73	151.19	20.54	2.63[a]
	159.90			151.19	8.71	1.34
		152.40	171.73		19.33	2.45[a]
	159.90		171.73		11.83	1.43
		152.40		151.19	1.21	.20
Trunk Flexibility	58.65	54.65			4.00	.84
			53.73	52.75	1.02	.21
	58.65			52.75	5.90	1.34
		54.65	53.73		.92	.18
	58.65		53.73		4.92	1.03
		54.65		52.75	1.90	.40

TABLE 6. Continued.

Item	Means				Diff.	t
	Lot Good (24)	Little Good (20)	Lot Poor (15)	Little Poor (29)		
Hip Flexibility	121.36	119.90			1.46	.30
			124.07	119.30	4.77	.72
	121.36			119.30	2.06	.40
		119.90	124.07		4.17	.65
	121.36		124.07		2.71	.41
		119.90		119.30	.60	.12
Ankle Flexibility	65.50	66.15			.65	.28
			67.00	64.14	2.86	1.02
	65.50			64.14	1.36	.51
		66.15	67.00		.85	.34
	65.50		67.00		1.50	.52
		66.15		64.14	2.01	.90

[a] Significant at 5 percent level of confidence.

in the first instance, the good program had the greater mean, lot-good vs. lot-poor; and in the second case, the lot-poor program had the greater mean, lot-poor vs. little-good. A rather high statistically significant mean difference was recorded for the lot-good vs. little-poor, 239.26 lbs.

4. Results similar to those obtained for leg lift strength were also found for back lift strength. Statistical mean differences ranged from 52.50 lbs. for lot-good vs. little-poor to 32.67 lbs. for the lot-poor vs. little-poor classification.

5. Four out of the six comparisons showed significant mean differences for arm strength. The two exceptions were lot-good vs. lot-poor, mean difference 8.49; and little-good vs. little-poor, mean difference 2.25.

6. Lung capacity showed no consistent trend. Three categories have statistically significant mean differences. In each case these were in favor of the subjects in the poor program and may, in part, be accounted for by the greater body size or maturation level of the boys in the lot-poor classification.

7. The three measures of flexibility of trunk, hip, and ankle did not show any definite statistically significant mean differences. The only suggestive difference was shown for the lot-good vs. little-poor group in trunk flexibility. All other t ratios range from .12 to 1.03.

Conclusions

The conclusions that appear valid as a result of this study of certain effects of physical education upon 12-year-old boys are as follows:

1. In this study, the two groups of 81 boys each, who participated in good and poor elementary school physical education for a period of three years, were found to be essentially alike in the maturity elements of chron-

ological age, skeletal age, weight, height, Wetzel developmental level, and McCloy's Classification Index I. However, differences between the two groups were definite for the following affective test batteries and affective test items: Physical Fitness Index, Indiana Physical Fitness Test, leg lift strength, back lift strength, vertical jump, and arm strength.

In view of the basic maturity similarity of the two age groups, it is concluded that the superior performance in the listed affective test items and batteries of the boys from the good programs are attributed to their participation in this type of physical education during their elementary school years.

2. The boys from both the good and poor programs who participated a lot in physical activities outside regular physical education classes demonstrated pronounced superiority over those who participated a little in such activities in the following affective measures: Physical Fitness Index, Strength Index, Metheny-Johnson Test of Motor Educability, Indiana Physical Fitness Test, vertical jump, arm strength, grip strength, leg lift strength, and back lift strength. There were also differences between the outside participation classifications in certain of the maturity elements; the lot-poor group was older (skeletally), taller, and heavier than the little-poor group, was taller and heavier than the lot-good group, and had a higher classification index than did the boys in the little-poor and lot-good categories.

From these results, the conclusion seems justified that boys who participate a lot in extraclass physical activities are superior in the affective elements listed to those who participate a little in such activities. Conclusions, however, as to whether the participation produces the superior boys or whether these boys participate in outside activities because they are superior, or whether the cause is a combination of these two, are not possible from this study.

3. In this study, statistically significant differences in the three flexibility measures included were not obtained for boys in the good and poor physical education programs nor were they found among the boys in the various categories based on extraclass physical activity participation. Inasmuch as the instrument used in measuring flexibility, the Leighton flexometer, had been well constructed and validated, it must be concluded that these test elements are not significantly affected in general by participation in the physical education and extraclass physical activities of the subjects.

4. The improvement of social and personal adjustment, as measured by the California Test of Personality, was not established in this study as a consequence of participation in good physical education programs or in a lot of extraclass physical activity. Conclusions on these findings are withheld until such time as other tests and techniques for evaluating such adjustment are applied to this problem.

(Submitted 5/26/60)

Notes and Comments

NOTES

Comparison of Two Methods of Measuring the Degree of Skill in the Underarm Volleyball Serve

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IT WAS THE PURPOSE of this study to determine the relationship between scores achieved on the velocity serve test (3) and accuracy scores attained on the French and Cooper Placement serve test (1). The velocity serve test is used to evaluate the flight of the ball by calculating the speed in feet per second. The French and Cooper test is used to measure the student's ability to place the place the ball in a marked area without regard to velocity.

Subjects

The subjects were 32 tenth grade girls in a beginning class in volleyball of the required physical education program at Councill Training School, Normal, Alabama. The class met five days a week, one-hour periods, for 12 weeks.

Procedure

The qualities of a good serve were discussed and demonstrated. Specifically, a good serve was defined as being low in relation to the net, having enough force to carry deep into the opponents' court and landing close to the target at which it is aimed. The goal was to develop the ability to project the ball using the single, underarm pattern so that the ball passed close to the net and went deep into the opponents' court. Serve velocities and corresponding ratings were set as shown by Table 1 (3). Periodic checks were made with the stopwatch so that each girl could determine her progress toward the goal. During practice sessions, a rope was placed 18 in. above the net to aid the students in developing kinesthetic awareness of the amount of force and the direction necessary to project the ball "close in relation to the net," i.e., between the rope and the net. Achievement of the goal resulted in the development of a neuromuscular pattern that was consistent with the definition of a good serve.

For the administration of the tests at the end of the 12-week period, the court was marked off so that scores on both the velocity serve test and the French and Cooper Placement serve test could be obtained simultaneously on each serve. Each girl was given ten legal trials to execute ten underarm serves. The writer observed the flight of the ball from contact with the hand to landing and recorded the time to the nearest 1/100 second and the distance to the nearest foot. Three class leaders were chosen to assist: one retrieving balls, two standing on opposite sides of the court to determine the spot where the ball landed. No scores were given for balls that landed outside the playing area. In case of disagreement concerning the landing point of the ball, the two concurring judgments were assumed to be correct. The initial velocity scores and the French and Cooper ratings, on each serve, were used in determining the results.

The initial velocity of each legal trial was calculated by using the following formulas:

1. Tangent of projection angle = ($\frac{1}{2}$ gt^2 — distance of starting point above contact point) ÷ the range.
2. Initial velocity = ($\frac{1}{2}$ gt^2 — the height of starting point above contact point ÷ the sine of the angle) ÷ the time of flight.

Results and Discussion

Reliabilities for these tests were determined by correlating odd-even scores using the Pearson-Product Moment Method. The resulting correlation for the velocity serve test was .97 and was raised to .98 for ten serves by the Spearman-Brown Prophecy Formula. The French and Cooper Placement Test had a reliability of .74 which became .84 for ten serves by application of the prediction formula. When the test scores of the two measures were correlated, the resulting coefficient was .159 which provided rather conclusive evidence that the tests were not measuring the same abilities.

While the velocity serve tests measured the student's progress toward an expressed goal in feet per second, the French and Cooper Test seemed to have two basic weaknesses: (a) it did not measure the degree to which a subject was able to execute her intentions by placing the ball in a stated area, and (b) it did not measure the subject's ability to execute a serve that was low in relation to the net, i.e., it did not measure the skill as it had been taught or as it was executed most efficiently.

The French and Cooper Test thus did not appear to accomplish its design, and hence its validity was subject to question. Ross and Stanley (2) describe this situation as being one of the outstanding sources of error involved in testing. Moreover, it is a major problem incurred in administering skill tests found in the most widely used textbooks.

Conclusion

Within the limits of the foregoing study, the author concluded that the reliability of the velocity serve test was considerably higher than that of the French and Cooper test and that the two tests were not measuring the same qualities of the underarm serve.

TABLE 1.—SERVING VELOCITIES AND CORRESPONDING RATINGS

Feet Per Second	Ratings
40 +	Excellent
38.0—39.9	Good
34.0—37.9	Fair
33.9 and below	Poor

References

1. French, Ester, and Cooper, Bernice. "Achievement Tests in Volleyball for High School Girls." *Research Quarterly* 8: 150-157, May 1937.
2. Ross, C. C., and Stanley, J. C. *Measurement in Today's Schools.* New York: Prentice-Hall, Inc., 1954.
3. Volleyball Staff, Women's Department of Physical Education, University of Wisconsin. "Suggested Guides for Analysis and Teaching Selected Volleyball Skills," 1955.

(Submitted 7/30/60)

Body Movement Awareness in the Nonhypnotic and Hypnotic States

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THIS CASE is reported because it is suggestive of an extensive body movement awareness which is apparently not ordinarily accessible to conscious verbal representation. Moreover, this case would seem to have some interesting implications for Henry's nonconscious "memory drum" theory of neuromotor control of movements (1).[1]

A baseball player who had volunteered to serve in an exercise physiology experiment involving hypnosis requested help in recovering his ability to bat well. By that time he had been trained to meet deep trance criteria (posthypnotic amnesia, compulsive response to posthypnotic suggestions, visual hallucinations, etc.).

While in the nonhypnotic state, the subject tried unsuccessfully to describe just what had gone wrong with his batting. He was then asked to enter a deep hypnotic trance and in this state was instructed to analyze his batting problem. Again he tried but was puzzled and frustrated by the effort.

He was then told that the investigator would present a signal which would elicit spontaneous verbalization. The signal was that the investigator would count to ten slowly and then rap on his desk. The subject was instructed to make no effort to analyze his batting problems but merely to sit and think of nothing. (It is emphasized that the investigator made no suggestions or comments to the subject which might have guided the analysis described here. It is also pointed out that the investigator at no time watched the subject play baseball.)

The signal was given. A few moments later the subject began to analyze his stance and batting movements. (The look of incredulity on the subject's face, as he talked, suggested that he was as surprised by what he had to say as the investigator was.) Starting with feet and legs, he took into account his pelvis, his arms, his grip on the bat, his swing, and his eyes. In each instance he named specific errors of timing, coordination, or position as the case might be. When asked if he would now be able to correct the mistakes which had given rise to the deterioration of his batting, he seemed confident that he would be able to do so.

He was then asked which would be better, to experience full conscious recall of his analysis posthypnotically or to have this knowledge "just come to him" as he practiced and played. Presently he stated that it would be better for it to come to him in time rather than to recall it posthypnotically.

The subject's batting performance improved immediately. And, indeed, he finished the season with a .400 average. He had by then acquired the reputation of being one of the best players in the region.

At the close of the season he returned to the investigator, giving him full credit for his comeback and success. He was asked whether he remembered what took place during the hypnotic session. He had not remembered it immediately afterwards, he said, but subsequently, it had come back to him. When asked just what had come to him, he stated that he remembered the investigator's analysis of what he was doing wrong in each specific movement and how he was using his eyes incorrectly; he said he remembered receiving hypnotic suggestions as to just how to correct his various mistakes. The subject found the explanation of what had actually happened difficult to believe until he was reminded that the investigator had never seen him play and could not possibly have been able to diagnose the problem or prescribe its solution.

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[1] The investigator is grateful to Franklin Henry for his prepublication explanation of the theory and for his critical reading of the present report.

Three points seem especially interesting in this case. 1. The subject's awareness of his movements and just what was wrong with them was detailed and readily verbalized under the special conditions established in the hypnotic state. Furthermore, if one may judge by the sudden improvement and persisting excellence of performance and by the coach's report to the investigator, the analysis was correct. 2. It would seem that the subject showed insight when he elected not to remember consciously the analysis of his motor skill, in that over-consciousness of complex movements seems to affect performance adversely. 3. Although posthypnotic amnesia obliterated out-of-trance awareness of what took place in the trance, in due course the subject "filled in" his memory in terms of his expectations regarding the session.

Reference

1. HENRY, FRANKLIN M., "Increased Response Latency for Complicated Movements and a 'Memory Drum' Theory of Neuromotor Reaction," *Research Quarterly* 31: 448-58; October 1960.

(Submitted 8/12/60)

Reliability of the 600-Yard Run-Walk Test at the Junior High School Level[1]

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SEVERAL QUESTIONS have been brought to the attention of the authors relative to the reliability of the 600-yd. run-walk item in the *Youth Fitness Test* of the American Association for Health, Physical Education, and Recreation. This study, an outgrowth of such questions, is an attempt to ascertain the reliability of the 600-yd. run-walk item with a sample of junior high school boys and girls.

As in all testing, pupil orientation and motivation is important. In this test the factor of extensive fatigue plays a part in the individual's performance. This is especially true with subjects in poor condition.

In the AAHPER 600-yd. run-walk test, the subject starts running the 600-yd. distance on command. He may walk if he desires but the object is to cover the distance in the shortest possible time. The question arises as to whether any one subject has a reliable score upon finishing the event. Is it his best performance? Is it a reasonable effort, or has it been haphazardly influenced by personal indifference, immediate and uncomfortable fatigue, etc.

Several studies have indicated that personal motivation is a major item when the stress and strain of physical performance increases (1, 2, 3, 5). Ulrich and Burke (4) demonstrated that the reaction of men and women to motivation techniques and motivation stressors advance or retard physical performance according to the success or failure feelings of the subjects.

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[1]This study was conducted as part of a University research project designed to stimulate measurement and research in health and physical education at the secondary school level.

The sample for the experiment consisted of 76 girls and 70 boys, all eighth grade students in junior high school. The AAHPER Youth Fitness Test was given initially and repeated one week later at the same period of the day and under the same relative outdoor temperature and weather conditions. Moreover, the same officials were used to check the subjects in both tests.

Approximately 15 subjects ran the 600-yd. run-walk at the same time. They were reminded that since this was an endurance and speed test they would have to run at a speed they could maintain, rather than a fast sprint used in a dash which would exhaust them in a short time. They were also instructed that if they could not continue running, walking was permissible. The object, however, was to cover the distance in the shortest possible time. Each subject had a partner who stood behind the timekeeper to listen for the partner's time as he or she crossed the finish line. These times were recorded immediately after the run.

The reason for testing the classes a second time a week later was explained. Students were told that the tests were being repeated to see if the 600 yd. run-walk was a reliable measure. Subjects were encouraged to run the event just as they did a week earlier. They were reminded that they were not out to break the record of the previous performance but to set their pace and do their best.

Results

The first and second scores for the 600-yd. run-walk for the 76 girls and 70 boys were compared in terms of rank order correlation between the scores on trials one and two, and difference between mean times on the two trials.

The coefficient of correlation between the first and second trials for the girls indicated a high degree of reliability, .92. A t of .574 indicates that no significant difference exists between the means of the girls group when the first and second trials are compared (Table 1).

The coefficient of correlation between the first and second trials for the boys also showed a high degree of reliability, .92. A t of .139 indicates that no significant difference exists between the means of the boys group when the first and second trials are compared (Table 1).

TABLE 1.—COMPARISON OF RANK ORDER CORRELATION AND MEAN TIMES OF FIRST AND SECOND TRIALS FOR THE 600-YD. RUN-WALK TEST

Trial	rho corr.	Mean (Seconds)	Differences Between Means		
			Diff.	S.E. Diff.	t
Girls I		159.4			
II	.92	157.7	1.70	2.96	.574
Boys I		132.4			
II	.92	132.0	.40	2.87	.139

Within the limits of this study, it seems reasonable to expect that when the 600 yd. run-walk is properly administered as a part of the AAHPER Youth Fitness Test it is a reliable measure of an individual's ability to endure the event. In view of the generally favorable physical condition of the junior high school age group, it would be interesting to repeat this experiment at the senior high school level. It might be demonstrated with the older age group that the stress of the event may limit personal motivation somewhat at random and thereby influence test reliability.

References

1. FAIRCLOUGH, R. H., "Transfer of Motivational Improvement in Speed of Reaction and Movement." *Research Quarterly* 23:20-27; March 1952.
2. HENRY, F. M., "Increase In Speed of Movement By Motivational Transfer of Motivated Improvement." *Research Quarterly*, 22:219-28; May 1951.
3. HENRY, F. M., "Independence of Reaction and Movement Times and Equivalence of Sensory Motivators of Faster Response." *Research Quarterly* 23:43-54; March 1952.
4. ULRICH, C., and BURKE, R. "Effect of Motivational Stress Upon Physical Performance," *Research Quarterly*, 28:403-12; December 1957.
5. VAUGHAN, J., and DISERENES, C. "The Experimental Psychology of Competition." *Journal of Experimental Education*, 7:76-97, 1938.

(Submitted 7/26/60)

COMMENTS

Comment on Investigations of RT/MT Relationships

IN A RECENT ISSUE of the QUARTERLY, Mendryk (3) has presented a study which came to the present writer's attention because it involved an area in which he had a personal research interest. The purpose of the Mendryk study was "to reevaluate the relationship between RT and MT for the 11-in. forward arm-thrust movement employed by Pierson, using the age ranges 10-13 years and 40-55 years (where his correlations were particularly high), as well as the age range 19-25 (where they were particularly low)."

In the same issue of the QUARTERLY, Henry (1) has made a plea for better reviews of the literature and Keogh (2) points out the confusion which results when conclusions are drawn from only selected portions of the data. Mendryk's study illustrates the reasons for these admonitions. He implies that Pierson's study (4) indicates a low correlation for ages 19-25 and high correlations for ages 10-13 and 40-45. The data of Pierson's study reveal that these correlation coefficients are .35 and approximately .35 and .85, respectively. Mendryk also has misquoted the reported correlation coefficient of RT and MT with the effect of age removed.

In his conclusion, Mendryk states, "For the age range studied, reaction time ability and speed of movement ability are uncorrelated; there is no influence of age on this relationship." Yet the correlation of RT and MT for his total sample resulted in a coefficient which was statistically significant at the .01 level, and he intimates that this is spuriously high because of the age factor. Mendryk also found a correlation between age and MT which was significant at the .01 level. Because this was an exception in a group of correlations which ranged from .034 to .091, he considered it to be an aberrant value appearing as a result of random error. The a priori theory of probability permits the statement that one of a hundred equally probable events may significantly differ at the .01 level. It does not, however, permit any inference as to which one. If conclusions are inferred from statistical analyses, the results of such analyses must be considered whether they agree with the investigator's preconceived notions or not. Henry[1] emphasizes this point when he states that it must be demanded of the research worker that he explore the weakness of his own theoretical positions even though they may be popular and generally accepted at the moment.

The results of studies by Pierson (4), Youngen (6), and Pierson and Rasch (5) have not been in agreement with those of other investigators. The one outstanding difference between the studies of these two groups has been in the method of movment termination. The former had their subjects breaking a photoelectric beam, and the latter, striking some object. It is not illogical to assume that greater progress toward the understanding of certain psychophysiological functions will be made by investigations of why than by reevaluations of current research findings.—*William R. Pierson, Biokinetics Research Laboratory, College of Osteopathic Physicians and Surgeons, Los Angeles, California.*

References

1. Henry, F. M. "A Plea for Better Scholarship in Research Reports." *Research Quarterly*, 31:234-36; May 1960.
2. Keogh, J. "Comments on the Selection of Data for Presentation." *Research Quarterly*, 31:240; May 1960.
3. Mendryk, S. "Reaction Time, Movement Time, and Task Specificity Relationships at Ages 12, 22, and 48 Years." *Research Quarterly*, 31:156-62; May 1960.
4. Pierson, W. R. "The Relationship of Movement Time and Reaction Time from Childhood to Senility." *Research Quarterly*, 30:227-31; May 1959.
5. Pierson, W. R. and Rasch, P. J. "The Generality of a Speed Factor in Simple Reaction and Movement Time." *Perceptual and Motor Skills*, 11:123-28; October 1960.
6. Youngen, L. "A Comparison of Reaction and Movement Times of Women Athletes and Nonathletes." *Research Quarterly*, 30:349-55; October 1959.

(Submitted 7/18/60)

Reply to W. R. Pierson's Comment by Stephen Mendryk

PIERSON HAS CHARGED that I have misinterpreted and misquoted his study on RT—MT correlations. I must plead guilty to one technical offense; I stated that the correlation he found (with age removed) was .33 instead of .31. Errors of this type unfortunately do occasionally occur; another example is seen in his own incorrect citing of reference 10 instead of 12.

Beyond this, I cannot accept his criticisms as valid. Lifted out of context and accompanied by misleading comments, my statements have been distorted as to intent and meaning. For example, he writes "Henry has made a plea for better review of the literature," thus implying that my review is poor. In fact, I handled the review as Henry recommends. Pierson makes a statement about the a priori theory of probability, implying that I have violated it. It is not in fact applicable to my results since I did not choose between one of several significant correlations. Nevertheless, he uses this as a basis for implying that I have failed to consider all of my data because some of it disagreed with my preconceived notions. Further facts are that the average of all my correlations between age and RT (or MT) within groups is only .12 and therefore below statistical significance. He selects for attack a sentence lifted out of my conclusions, in which I said that RT and MT are uncorrelated and that age has no effect on this relationship. Had I anticipated his attack, I would have phrased the sentence more skillfully. I assumed that it would be read and interpreted in the context of my study and title. It should be clear to anyone that this conclusion referred to the size of the RT—MT correlation in different age groups that were internally homogeneous. In fact I demonstrated how age heterogeneity caused a significant RT—MT correlation. Pierson quotes only the first half of my formal "problem investigated" statement, and even that quotation is incomplete in that it omitted a phrase that I consider important. After reviewing the literature briefly, I stated: "Considering the above results, it seemed desirable to reinvestigate the relationship . . . ." The next paragraph begins: "It was

decided to broaden the problem by including . . . ." On page 160 of the Research Quarterly article I discussed "why." Pierson has therefore made an incorrect implication in the concluding sentence of his critical note.

He implies that I misquoted his correlation of .35. In fact, I said that he found a correlation of .35 for 40 subjects of college age. Elsewhere in his article, specifically in the first few lines of his introduction and the first few lines of his discussion, he made statements that I interpreted to mean that it was his position that the RT—MT relation was low for college age students, but that this was not representative of other age groups. I leave it to the reader to examine his statements in context and decide if I have misinterpreted or misquoted him. I stated that his correlations were particularly high for the age ranges 10 to 13 years and 40 to 55 years and particularly low for the age range 19 to 25 years. This was because I read from his Figure II the following correlations: .45 at age 10; .37 at age 11 and .50 at age 12 (average, .44); .82 at age 45 and .85 at age 51 (average, .84); zero at age 20 and .55 at age 23 (average, .30). In a sincere effort to structure my experiment in a manner that would offer good possibilities for showing that the RT—MT correlation for the college age was not representative of the correlation in other age groups, I sampled subjects in the age groups listed above. It is common knowledge that the best estimate of a population statistic is furnished by the sample statistic.

The movement that I used was nonterminated. "The subject responded . . . by striking the target with fingertips and continuing the movement . . . with follow through. Since the target was light and easy to move, the slightest touch of the fingertip . . . caused it to turn . . . ." The target was made of thin transparent celluloid. The movement was the same as that used by Pierson; I gave the same amount of practice and used the same system of "representative scores."

In the final analysis it is up to the reader to evaluate what I said in print, in relation to the facts that were presented and in relation to the Pierson attack. Perhaps it is these facts rather than what I have said that has brought down the Piersonian wrath about my head.—*Stephen Mendryk, University of Alberta, Edmonton, Alberta.*

(Submitted 3/20/61)

Comments on the article by Glen H. Egstrom, Gene A. Logan, and Earl L. Wallis, "Acquisition of Throwing Skill Involving Projectiles of Varying Weights" in the October 1960 Research Quarterly

The results of the experiment described in this article are additional evidence in support of the statement by Bartlett (1) that "very generally there is more positive transfer from the relatively difficult to the relatively easy than from the relatively easy to the relatively difficult." Higher scores were made with the heavier ball both in the initial and final learning tests, so clearly the easier task in this particular set-up was the one in which the heavier ball was used. One would therefore expect more transfer from throwing the light ball to throwing the heavier ball than vice versa. It would be interesting to repeat the experiment using such a heavy ball that the task with it became the more difficult. One would then expect that the greatest transfer would be from throwing the heavier ball to throwing the lighter one. This would then cast doubt on some of the points made in the discussion to the above article.—*Barbara Knapp, Physical Education Department, University of Birmingham, Birmingham, England.*

Reference

1. BARTLETT, F. C. "The Experimental Study of Skill" *Research* 4: 217-221; 1951.

(Submitted 1/1/61)

Research Abstracts

Prepared by the Research Abstracts Committee of the Research Council, D. B. VAN DALEN, Chairman

17. AMERICAN HEART ASSOCIATION. "Cigarette Smoking and Cardiovascular Diseases." *Circulation* 22: 160-66; July 1960.

This report reviews experimental, clinical and statistical studies of the relationship between cardiovascular disease during the period 1956 to 1960. There is conflicting experimental evidence as to the cause of the increased heart rate, elevated blood pressure, and flattened T wave in the ECG after smoking. Increased work of the heart or constriction of the coronary arteries are suggested as possible causes.

Statistical studies indicate a clear relationship between increased cigarette smoking and increased rate of death from coronary heart disease. However, the role of cigarette smoking as a causative agent in coronary heart disease is less clear cut.—*Clifford E. Keeney.*

18. ASMUSSEN, E., and HEMMINGSEN, F. "Determination of Maximum Working Capacity at Different Ages in Work With the Legs or With the Arms." *Federation Internationale D'Education Physique Bulletin* 2: 13-19; 1959.

It is possible to predict the aerobic capacity from measurements made from submaximal work using the large muscles of the lower extremities. In this study it was found that an accurate estimate of the maximum capacity for arm work can be deduced for submaximal work performance in the same way as for leg work. It is, however, not possible to estimate the total aerobic capacity for leg work from experiments with arm work and vice versa.—*Hollis F. Fait.*

19. BAILEY, JAMES A. "Practical Sportsmanship—A Unique Contribution of Physical Education and Athletics." *The Physical Educator* 17: 128-30; December 1960.

Learning and dispositions in the area of social behavior do not automatically accrue as a result of participation in athletics. They must be planned for and worked toward just as must every other learning. The author has constructed a rating scale designed to make students aware of specific items of desirable social behavior in athletics. The self-rating chart includes the following: health habits, cooperation, conservation, tolerance, courtesy, personal direction, and critical judgment.—*Hollis F. Fait.*

20. BRAUNWALD, EUGENE; KELLY, EUGENE R.; and BULLOCK, FREDERICK A. "The Effects of Exercise on Central Blood Volume in Man." *Journal of Clinical Investigation* 39:413-19; February 1960.

Considerable difference of opinion exists regarding the influence of muscular exercise on central blood volume. Ten male subjects were studied while pedaling an ergocycle. The "central blood volume" was considered to represent the volume within the vascular bed between the site of injection in the right atrium or superior vena cava and the site of sampling in the brachial artery. The mean increase in central blood volume was 285 ml. During 20 minutes of recovery there was a mean decrease of 375 ml. During exercise the oxygen consumption increased from a mean of 144 to 1.011 ml/min/M^2BSA, while the cardiac index rose from a mean of 3.42 to 7.99 L/min/M^2BSA. It appears that the optimal cardiovascular response to exercise is characterized by an augmentation of central blood volume accompanying an elevation of cardiac output commensurate with the increased peripheral oxygen requirements.—*P. J. Rasch, Journal of the Association for Physical and Mental Rehabilitation.*

21. BROWN, ROBERT H. "Weber Ratio for Visual Discrimination of Velocity." *Science* 131: 1809-10; June 1960.

An approximation based on experimental reports in the literature indicates that the least detectable difference in velocity (w) varies in direct proportion to the velocity (W), over a range of from 0.1 to 20 degrees of visual angle per second. Like the Weber ratio in other sensory discrimination phenomena (w/W), velocity discrimination is a logarithmic function of the velocity and can be plotted as a straight line on a log-log plot.—*Clifford E. Keeney.*

22. BURGER, H. C. "The Significance of the Flow/Volume Diagram in the Study of the Mechanics of Breathing." *Proceedings of the Tuberculosis Research Council* (Netherlands) 46: 28-47; 1960.

Simultaneous recordings of oesophageal pressure, tidal volume, and air flow were obtained on 31 patients and healthy subjects. The characteristics of the above factors in coughing or wheezing expirations are discussed in relation to recordings obtained of healthy subjects.—*J. Royce.*

23. CHRISTENSEN, E. H. "Intervallarbeit und Intervalltraining" (Intermittent Work and Training). *Internationale Zeitschrift für angewandte Physiologie einschliesslich Arbeitsphysiologie* 18: 345-56; 1960.

One well-conditioned male subject (age 26) performed a series of bicycle ergometer rides at a load of 2520 KGM/min for 10, 15, 30, and 60 seconds with rest periods which varied between 20 and 240 seconds. The oxygen consumption, minute volume, and heart rate were measured. The results showed that the physiological workload is primarily determined by the length of the work phase, while the duration of the rest period is of secondary importance. The oxygen need during short work periods may for a substantial part be filled by oxygen released from myoglobin. The importance of this factor in industrial work, where short-duration work periods are prevalent, is discussed—*J. Royce.*

24. DAHL, L. K. "Effects of Chronic Excess Salt Feeding: Elevation of Plasma Cholesterol in Rats and Dogs." *Journal of Experimental Medicine* 112: 635-51; October 1960.

Among female rats and dogs which were fed excess salt for periods of about one and four years, respectively, elevations in plasma cholesterol concentrations were frequent and in some cases, quite marked. Rats on a similar regimen but for a much shorter period of time showed lesser elevations of cholesterol.

The lipid changes did not appear to be related to increased blood pressure, differences in body weight, or food consumption. There is no present evidence which suggests that this phenomenon is related to atherogenesis although it was speculated that this was possible.—*R. H. Rochelle.*

25. DEMING, Q. B., AND OTHERS. "Blood Pressure, Cholesterol Content of Serum and Tissue, and Atherogenesis in the Rat." *Journal of Experimental Medicine* 107: 581-98; April 1958.

Rats fed a stock diet with added cholesterol and cholic acid developed increased concentrations of cholesterol, total lipids, and beta lipoprotein in the serum and an increased content of cholesterol in the liver and carcass. Hypertension accelerated the development of hypercholesterolemia, hyperlipemia, and atherosclerotic changes in the intima as well as increases in tissue cholesterol. Significant positive correlations were found between the extent of atherosclerotic lesions and the concentration of cholesterol in the serum and blood pressure and the degree of hypercholesterolemia.—*R. H. Rochelle.*

26. DIETZE, ALFRED G. "Kinaesthetic Discrimination: The Difference Limen for Finger Span." *The Journal of Psychology* 51: 165-68; January 1961.

With vision occluded, the subjects attempted to designate whether aluminum rods of

varying lengths were smaller or larger than comparison stimuli presented. Three series of rods were used with comparison standards of 50, 30, and 10 mm. Subjects extended thumb and forefinger, moved them together to touch the bar and then separated them again. The experimenter substituted the comparison stimulus for the subject to grasp and report his judgment. Four hundred judgements around each standard were made by each subject.

Results agreed with the findings of Langfeld and Gaydos that there is a lawfulness in the ability to perceive spatial differences kinaesthetically and that this capacity is keener than is usually thought to be true. Subjects discriminated differences of 1/50 of standards set at 50 mm. or 30 mm. and 1/20 of a standard set at 10 mm.—*Helen Zimmerman.*

27. Espinosa, L. J., and Iborra, J. E. "Knock-out and Syncope in Professional Boxing." *Electroencephalography and Clinical Neurophysiology* 12: 196-97; February 1960.

An EEG study. Three boxers who had been knocked out once or more were examined and a fainting condition of syncopal aspect was found in two cases and a typical syncope found in the third with a cardiac pause of 16 seconds discovered by means of the Oculo-cardiac-reflex.—*C. Etta Walters.*

28. Eysenck, S. B. G. "Retention of a Well-Developed Motor Skill After One Year." *Journal of General Psychology* 63:267-73; October 1960.

Eight subjects aged 20 to 40, four men and four women, practiced on a pursuit rotor for a 15-minute period five days a week for ten weeks—a total of 50 periods. After an interval of one year, they were retested for three periods. There was a decrement of only 10 percent on the first trial after the year rest, and performance on the last two trials was slightly better than the prerest performance. The authors conclude that retention of a perceptual-motor habit is remarkably good, even after one year's rest. —*Bruce L. Bennett.*

29. Fletcher, J. G., and Lewis, H. E. "Human Power Output: the Mechanics of Pole Vaulting." *Ergonomics* 3: 30-34; January 1960.

Slow motion cinephotography has been used to study the performance of five pole vaulters. By plotting the trajectory of the center of gravity, as determined by preliminary experiments with a manikin, it can be shown that most of the energy required is stored in kinetic form during the run-up. Unfortunately, a high initial speed (high initial kinetic energy) seems to be attended by correspondingly large losses during the rest of the vault. Apparently, the most successful performers take off at moderate speed and add to their energy by active performance of work while they are swinging up on the pole.—*David H. Clarke.*

30. Freeman, Howard E., and Kassebaum, Gene G. "Relationship of Education and Knowledge to Opinions about Mental Illness." *Mental Hygiene* 44: 43-47; January 1960.

Information was obtained from 483 adults on 31 items used to determine a person's conception of mental illness by the Washington Public Opinion Laboratory in 1950. Correlations between the variables were computed. Results indicated that the relationship between formal education and opinions regarding the etiology and prevention of mental illness was weak (correlation of .10). There was a strong correlation between formal education and knowledge of technical vocabulary, but a low correlation between education and recognition of neurotic symptoms. The writers conclude that opinions of a person may not be altered by the facts and that health educators need to know more about the frames of reference by which people integrate factual information and personal opinion.—*Bruce L. Bennett.*

31. FRIEDBERG, S. J., AND OTHERS. The Effect of Exercise on the Concentration and Turnover of Plasma Nonesterified Fatty Acids." *Journal of Clinical Investigation* 39: 215-20; January 1960.

Recent work has suggested that the albumin-bound fatty acids of the blood (FFA) might be oxidized directly by muscle. Few human experiments on this subject have been published and little information is available. A study of male volunteers exercising on a stationary bicycle showed that exercise lowers FFA by accelerating its removal from the blood. The fate of the removed FFA was not determined. There is a significant rise in plasma FFA concentration immediately after exercise.—*P. J. Rasch, Journal of the Association for Physical and Mental Rehabilitation.*

32. FRIEDMAN, MEYER, AND OTHERS. "Excretion of Catecholamines, 17-Ketosteroids, 17-Hydroxycorticoids and 5-Hydroxyindole in Men Exhibiting A Particular Behavior Pattern (A) Associated With High Incidence of Clinical Coronary Artery Disease." *Journal of Clinical Investigation* 39: 758-64; May 1960.

The urinary excretion of 17-ketosteroids, 17-hydroxycorticoids, 5-hydroxyindole, epinephrine, and norepinephrine was measured in 12 subjects (men) exhibiting an overt behavior pattern (2) and 12 exhibiting behavior pattern (b), the converse of A during working hours and after working hours. Overt behavior pattern (2) was characterized by excessive and competitive drive to excel and an enhanced sense of time urgency.

The serum cholesterol of the men of group A (276 mg per 100 ml) was significantly higher than that of Group B. Also, the blood clotting time was faster in men of Group A. The urinary excretion of the above listed hormones was found to be the same in both groups, for both conditions, working hours and sleeping. The exception to this was in norepinephrine, when a greater increase was found during working hours in the men exhibiting Pattern A than in the central group—*R. H. Rochelle.*

33. FRYMIER, JACK R. "Faculty and Student Perceptions of Cheating." *Journal of Educational Research* 54:118-20; November 1960.

This study ascertained and compared faculty members' and students' perceptions of cheating. An instrument developed by William F. Anderson, Jr., which determines students' perceptions of cheating, was sent to 177 faculty and 130 university students. The data indicated that there seems to be very little basic difference in the orientation of the two groups toward cheating. The over-all pattern of perceiving various behaviors as cheating or noncheating seems to be quite similar although faculty members seem to be more severe in describing a particular behavioral act as cheating than are the students. Both groups seem to agree that getting help *before* an examination is usually justifiable, but getting assistance *during* the exam or by any covert means is inappropriate.—*Vera Skubic.*

34. GARN, STANLEY M., and HASKELL, JOAN A. "Fat and Growth During Childhood." *Science* 130: 1711-12; December 1959.

Fat thickness measured radiographically by fat-plus-skin shadow in both sexes is positively and significantly correlated with body length and maturity status indicated by epiphyseal union of the tibia and age at menarch in girls, for the ages 1.5 to 11.5 years.—*Clifford E. Keeney.*

35. GOLDSTEIN, M. S. "Glucose Transport Theory of Insulin Action." *Annals of the New York Academy of Sciences* 82: 378-86; September 25, 1959.

A barrier to the entry of sugars exists at the surface of cells of skeletal muscles, heart, and adipose tissue. This barrier is overcome by a specific system which transports glucose from the extracellular to the intracellular position. Forced vigorous contraction of large masses of skeletal muscles releases some humeral factor which activates this system and augments rates of intracellular transport of the same sugars that are acted upon by insulin. Of the transport systems present, those related to glucose could be viewed as existing in some state of inhibition relieved by insulin and by some humeral

factor released from strenuously exercising muscle. The precise nature of the transport system may be a function of the particular tissue and the particular animal species. —*P. J. Rasch, Journal of the Association for Physical and Mental Rehabilitation.*

36. GRUNWALD, A., and SILBERMAN, Z. "Anterior Tibial Syndrome." *Journal of the American Medical Association* 171: 2210-13; December 19, 1959.

Football players have experienced severe pain in the anterior tibials after strenuous exercise, followed by difficulty in moving the foot and toes. There are two main theories of the pathogenesis of muscle changes: (a) it results from vascular spasm or other vascular changes; (b) the retention of fluid in the muscle, edema, and small hemorrhages produces a rise in tension which impairs the circulation and may lead to necrosis. The latter appears the more likely. The leg must be kept at absolute rest and the tension must be relieved by incising the fascia.—*P. J. Rasch, Journal of the Association for Physical and Mental Rehabilitation.*

37. HALLIDAN, JOHN A. "Blood Flow in the Human Calf after Prolonged Walking." *American Heart Journal* 60:110-15; July 1960.

Blood flow was measured in the calves of three subjects before and after walking around an outdoor track for distance ½, 1, and 2 miles, and at rates of 3 mph and 5 mph. Hyperemia was increased directly with the distance walked at the 5-mph rate, however, at the 3-mph walking rate, distance had only slight effect in eliciting hyperemia. It was concluded that at 3 mph the blood flow requirement is adequately met, but at 5 mph excess blood is needed by the muscles and the amount needed increases with the distance walked.—*Clifford E. Keeney.*

38. HANSEN, D. E., and MAGGIO, M. "Static Work and Heart Rate." Internationale *Zeitschrift für angewandte Physiologie einschliesslich Arbeitsphysiologie* 18: 242-47; 1960.

Two untrained male subjects (age 32) performed on the bicycle ergometer at a workload of 300 KGM/min for about 10 minutes when static work was added. Weights of 2 kg each were held for 1.5 min. in each hand with the arm abducted. Oxygen intake and pulse rates were determined. The pulse rates increased immediately after the start of the static work and diminished faster than the oxygen intake after the work period was terminated. The disproportion between increase in pulse rate and increase in oxygen consumption induced by static work is discussed. The most likely explanation seems to be found in a nervous heart rate regulation mechanism which is initiated by a stimulus of a constant nature. It is stressed that the pulse rate does not clarify the role of fatigue induced by static work.—*J. Royce.*

39. HEINONER, A. O.; KARVONEN, M. J.; and RUOSTEENOJA, R. "The Energy Expenditure of Walking on Snow at Various Depths." *Ergonomics* 2: 389-94; August 1959.

The energy expenditure of walking at natural pace on snow of various depths was determined for seven males. Results were expressed as a function of the depth of the depression of the feet into the snow. Depressions of 0, 10, 20, 30, and 40 cm gave an energy expenditure of 0.63, 1.42, 2.65, 5.72, and 8.30 cal/kg body weight per horizontal meter, respectively. The energy expenditure could be expressed as a linear function of the depression, using two equations, one for depressions less than, and the other for those greater than 15 cm. The results are discussed.—*David H. Clarke.*

40. HODKINSON, H. M.; MORRIS-OWEN, R. M.; and WILLIAMS, H. M. "Judo." *Lancet* 7129: 883; April 16, 1960.

The health and educational values of judo deserve serious attention. The most direct application of judo skill to ordinary life comes from the training and constant habituation to falling safely from all angles. More important is its influence on personal development and its enjoyment value. Even a very weak novice can adapt himself to the demands of judo training and get something positive out of the sport. Major benefits

include physical development, the learning of principles of posture and movement, and improvement in emotional poise. Of course, the sport requires effective supervision and competent instruction.—*P. J. Rasch, Journal of the Association for Physical and Mental Rehabilitation.*

41. HONKAVAARA, S. "An Attempt to Measure Intelligence in Terms of Organic Development." *The Journal of Psychology* 45: 37-42; January 1958.

The author attempted to construct a test which measures intelligence in terms of organic development, eliminating school learning and the influence of environment. Three modes of behavior were dealt with: dynamic-affective, concrete, and conceptual. Bright and backward boys and girls five through eight years of age were the subjects. The test consisted of naming objects, grouping them, and telling the reasons for the groupings made. If the child stated correctly that the objects shown him were of one kind or that they were used together (buttons, thread), this was considered a sign of abstract behavior. Evidences of concrete behavior were the selections of different types of objects of the same color, size, or shape and the explanation of this basis of selection. Dynamic-affective behavior was shown when the child placed his favorite toys and gaudy things together because he liked them. Subjects were asked to regroup objects in a second way, and, if unable to do so, were asked whether or not the experimenter did it correctly. The test was repeated three times with different objects.

The results showed that in the 8-year-old group, backward children with two exceptions responded only on the concrete level. At this age bright children did abstract thinking. Only three 8-year-olds used dynamic-affective behavior. At five years, even the bright children were incapable of abstract behavior. Both bright and backward groups did concrete thinking, but only the backward children showed dynamic-affective behavior.

The author points to this experiment as an example of the branching-out process in the development of intelligence. He questions whether, with additional verification of his findings, it would be possible to predict that when two 5-year-old children perform with equally limited results, the child who does not show dynamic-affective reactions is not backward.—*Helen Zimmerman.*

42. HYMAN, CHESTER, and WINSOR, TRAVIS. "Application of the Segmental Plethysmograph to the Measurement of Blood Flow through the Limbs of Human Beings." *Journal of Cardiology* 6:667-71; September 1960.

The authors describe an accurate method for the plethysmographic measurement of blood flow in the extremities of human subjects by the use of a "segmental plethysmograph." This instrument is most suitable for the measurement of blood flow immediately after exercise, since the necessary equipment is maintained on the subject during the exercise. The system involves an air-filled cuff which can be wrapped around any portion of the extremity, and a sensitive, balanced volume transducer which can be readily and accurately calibrated against a standard volume in increment. A comparison of the segmental plethysmorgraph with the classic water-filled plethysmorgraph resulted in a close relationship.—*R. H. Rochelle.*

43. JACKSON, K. F. "Behaviour in Controlling a Combination of Systems, II. Effects of Changes in the Velocity of Disturbances." *Ergonomics* 2: 363-66; August 1959.

A multiple-tracking task study was made to determine the effect of operator behaviour of uniform variation in the velocity of disturbances affecting a set of four dials. Twelve subjects were instructed to key the various pointers as near to zero as possible, while these dials were systematically affected. Results indicated that they did little to compensate for the added difficulty of task, although the speed of their control movements did rise proportionally to the velocity of disturbance and hence proportionally to the errors that they encountered. Apparently the more difficult the task the worse the condition they would tolerate, while at the same time they were prepared to make faster control responses.—*David H. Clarke.*

44. JACOBS, HARRY L., and others. "A Hydrostatic Oil Bearing Turntable System for the Laboratory Study of Some Aspects of Weightlessness." *Perceptual and Motor Skills* 11:333-35; December 1960.

One concomitant of free-fall is the complete absence of bearing contact. This can be approximated for angular motion in the horizontal plane by standing on a free rotating, low friction platform. An externally pressurized oil bearing system is described which has been used to study performance under these conditions and to determine whole body movement of inertia.—*D. B. Van Dalen.*

45. JARRARD, LEONARD E. "The Role of Visual Cues in the Performance of Ergographic Work." *Journal of Experimental Psychology* 60: 57-63; July 1960.

The research attempted to provide a more precise specification of the effects of psychological factors in the activation of the human neuromuscular system. The specific problem was to determine the extent to which muscular tension and ergographic performance are affected by set toward the amount of work to be done. The independent variable of set was varied by employing the size-weight illusion in such a way that subjects in the experimental conditions changed from lifting one weight to a second weight that physically weighted the same but differed in size (smaller or larger). The subjects in one control condition could not see the weight they were lifting. The subjects in two other control conditions could see they were lifting the same weight at all times. The principal results were as follows:

1. Muscular tension was significantly higher in those subjects who changed to the weight that they had previously judged heavier. The reverse did not hold for subjects who changed to the weight that they had judged lighter.

2. There was a direct relationship between set toward the amount of work to be done and work output as indicated by the number of lifts to exhaustion, i.e., those subjects who changed to the heavier weights lifted significantly fewer times than control subjects while those subjects who changed to the lighter weight lifted significantly more times than the controls.

Thus, there were peripheral changes that accompanied one condition of set but the procedure was such that peripheral changes were not recorded when an opposite set was given. That set was still operating but primarily at a central level is suggested by the performance measures obtained for the condition in which no peripheral changes were recorded.—*Vera Skubic.*

46. JARVINEN, KLAUS A. J. "Physical Activity of Patients After the Onset of Acute Cardiac Infarction." *British Medical Journal* 5177: 922-25; March 26, 1960.

Complete physical rest is commonly held to be the guiding principle in the treatment of acute myocardial infarction. But attacks are often followed by marked restlessness, associated with severe pain. The patient may get up and walk about in his agony. A study of 102 men and 31 women showed that 72 percent of the men kept moving after the onset of acute myocardial infarction, some of them walking long distances. All of the women immediately stopped work. The response of the men was unwise, as it appears that if physical activity is prolonged, the outcome may be fatal. This may account for the high mortality from acute myocardial infarction among men.—*P. J. Rasch, Journal of the Association for Physical and Mental Rehabilitation.*

47. JONES, FRANK P., and GILLEY, PHILIP F. M., JR. "Head-Balance and Sitting Posture: An X-Ray Analysis." *Journal of Psychology* 49: 289-94; April 1960.

The positions of the head during three sitting postures, one relaxed and two erect, were studied. The first erect head position was that which the subjects normally assumed in response to the request to sit up. The second was a position achieved when the experimenter, holding the back of the head, moved it "forward and up" as the subject sat up. The usual change in the reflex balance of the head when moving against gravity was prevented. The 20 male student subjects reported the experimental posture

easier to maintain. It involved less feeling of weight than accompanied the relaxed posture and required less effort than the normal erect sitting posture.

To study the positions, linear and angular measurements were made of x-ray photographs taken in three sagittal planes. Differences having high degrees of statistical significance were found between the two erect postures in all measures except the neck angle (intersection of the vertebral plane with the horizontal). In the experimental posture, the angle between the head and the horizontal was smaller; that between the head and neck, larger. Sella turcica was lower and the space between the spines of the first two vertebrae had increased. As an explanation of the differences the authors propose the hypothesis that a change takes place in the balance of forces that control posture. In the habitual relaxed position, with the center of gravity forward of the base of support, the torque placed on the head affects the muscles and ligaments of the back of the neck and through them the spines. In the habitual erect posture the center of gravity is raised and the head rotated backward eliminating the gravitational torque and the stretch of the neck extensors. In the experimental posture, the extensors lengthen as the position is taken, thus preserving the mechanical advantage of tonic facilitation from the head and resulting in the feeling of decreased effort. Further studies on the subject are in progress.—*Helen M. Zimmerman.*

48. JOHNSTON, WILSON. "Vitamin E for Athletes." *Lancet* 7129: 882; April 16, 1960.

Vitamin E is given extensively to athletes in Australia. Experiments with English athletes gave impressive clinical results in that it appeared to produce increased stamina and delayed fatigue. Comprehensive studies under controlled conditions are now being undertaken.—*P. J. Rasch, Journal of the Association for Physical and Mental Rehabilitation.*

49. JOURNAL OF EDUCATIONAL SOCIOLOGY. "A Report of the First National Community School Clinic." *Journal of Educational Sociology* 33: 145-208; December 1959.

This entire issue is devoted to a report of this clinic which was co-sponsored by the AAHPER and the Mott Foundation Program of the Flint (Michigan) Board of Education. It was held in March 1959, at Flint. Some 300 delegates from 30 states attended. Of special interest is a description of the Mott Foundation program in Flint which has received national recognition as an outstanding example of a school-community program in action.—*Bruce L. Bennett.*

50. KAMINAR, BENJAMIN. "Blood Pressure in Bushmen of the Kalahari Desert." *Circulation* 22: 289-95; August 1960.

Blood pressure was measured in 42 men and 36 women of two nomadic groups of Bushmen near Ghanzi in the Kalahari Desert, and a third group of 21 Bushmen prisoners and farm laborers from the same region. Average systolic pressure in the men was 108.4 mm Hg with a standard deviation of 11.4 mm. In women the average systolic pressure was 112.8 with a standard deviation of 14.6 mm. Diastolic pressure was 66.2 $\pm$ 6.9 mm in the men, and 69.6 $\pm$ 8.0 in the women. The pressure is lower than in most populations, in addition it is unusual to find blood pressure in women higher than in men. The blood pressure of this sample showed no tendency to increase with age.—*Clifford E. Keeney.*

51. KODMAN, FRANK, JR., AND OTHERS. "Psychosocial Characteristics of Adults with Functional Hearing Losses." *Perceptual and Motor Skills* 11: 23-27; August 1960.

A sample of 100 cases with functional hearing losses were compared with a control group of 96 hard of hearing cases. The two samples were equated for sex, chronological age, and degree of hearing loss. The samples were compared on the basis of mean income, duration of military service, number referred for psychiatric examination, occupational status, type of loss (monaural or binaural), and number of psychosomatic complaints.

The following are the major findings: (a) a nonsignificant difference was found be-

tween the group with functional hearing losses and a hard of hearing control group on three variables—income, duration of service, and the number referred for psychiatric evaluation; (b) a statistically significant difference was found between our two groups as to the number of binaural versus monaural losses, occupational classification, and number of psychosomatic complaints. The descriptive results in this study should not be interpreted as reflecting a causal relationship between functional hearing loss and the variables studied.—*D. B. Van Dalen.*

52. LANCET, Medical Officers of Schools Associations, Report of January Meeting. *Lancet* 7117: 209-10; January 23, 1960.

Boxing was the topic of discussion at the January meeting. Dr. MacDonald Critchley warned of the danger of concussion of the medullary centers in the mid-brain and the harm that may arise from it. Dr. J. A. Waycott stressed the point which distinguishes boxing from all other sports: the injuries are intentionally inflicted. Others argued that properly supervised amateur boxing was of great value. Several speakers urged that judo be substituted for boxing, as it was superior as a means of self-defense and the rules are designed to avoid injury. Fencing was also recommended as a substitute.—*P. J. Rasch, Journal of the Association for Physical and Mental Rehabilitation.*

53. LIPPOLD, O. C. J.; REDFEARN, J. W. T.; and VUCO, J. "The Electromyography of Fatigue." *Ergonomics* 3: 121-31; April 1960.

The changes in the electrical activity of calf and hand muscles during and following fatigue are discussed. There are changes in size and form of the action potential and in the synchronization of firing between motor units. In fatigue which follows a short strong contraction, the electrical changes depend on peripheral factors, mainly the failure of the contractile mechanism to produce as much tension as in the normal state. Thus, as the contraction proceeds, the integrated electrical activity in a muscle exerting a constant tension increases gradually. When the contraction ceases, the electrical activity falls rapidly to its unfatigued level. An arterial occluding cuff prevents this recovery, if inflated at the end of the contraction. Muscular tremor is increased during and after muscular fatigue.—*David H. Clarke.*

54. LLOYD, R. GRANN. "Admission Policy in State-Supported Higher Education." *School and Society* 88: 446-47; November 19, 1960.

A survey study was made to get information on whether or not the various states require all state-supported colleges and universities within their borders to accept any graduate of high school who makes application for admission, regardless of mental aptitude and other factors. Returns from the questionnaire were received from all 50 states, Puerto Rico, and the District of Columbia. The findings indicate that the majority of these institutions of higher learning are becoming much stiffer in their entrance requirements. The often repeated statement that state-supported colleges and universities must accept any high school graduate from the state is untrue in most cases.—*T. Erwin Blesh.*

55. MORRIS, WILLIAM E., and JENSEN, MILTON B. "Recreational Preferences as Predictors of Participation in Mental Hospital Activities." *Mental Hygiene* 45: 77-83; January 1961.

Mental hospital patients were asked to give a rank-order preference for nine groups of recreational activities. They were then assigned to activity groups and the degree and enthusiasm of their participation was rated by recreational workers. It was not surprising to find that participation was related to preference; i.e., they were more active in the preferred activities. Of more interest is the fact that in a follow-up study 21 months later, those who had left the hospital preferred active sports over quiet sports. Those still in the hospital preferred quiet sports. The authors state, "It is a favorable sign for men to prefer active sports."—*Bruce L. Bennett.*

56. MOWBRAY, G. H. "Choice Reaction Times for Skilled Responses." *Journal of Experimental Psychology* 12: 193-202; November 1960.

Two kinds of choice reaction time experiments were reported, both of which make use of a highly overlearned sensorimotor response. When a response is required for each stimulus presented, no increase in reaction time occurs as a function of the number of alternative stimuli available. It is proposed that the increase in choice reaction times commonly thought to accompany an increase in the number of alternative choices provided reflects the unpracticed state of the responder. When a response is required for only one out of n possible stimuli, a slight but consistent increase in reaction time takes place with an increase in the number of alternatives.—*Vera Skubic.*

57. NEA RESEARCH DIVISION. "The Financial Rewards of Teaching." *NEA Research Bulletin* 38: 49-55; May 1960.

For the calendar year 1959, the average salary of teachers was $5,013. This was the first year the salary of instructional staff in public elementary and secondary schools exceeded $5,000. For the year 1959-60, there were a few losses and some gains, but no striking changes in the salaries of teachers in relation to earnings of other workers in the economy. Trends which have been noted in previous years are continued:

1. From 1939 through 1959, average annual earnings of all persons working for salaries and wages increased more than the average annual of salaries of teachers.
2. Gains in average salaries of teachers have exceeded increases in the cost of living each year since 1951. Over the past ten years, gains in teachers' salaries in excess of cost-of-living increases amounted to 41 percent.
3. The average annual earnings of teachers in 1958 were less than 50 percent of the average earnings of a combined group of 17 other professions, including both high and low income groups requiring college education.
4. Men graduates of the class of 1960 recruited for employment by business and industry will be offered starting salaries averaging more than $1,000 above starting salaries in teaching. These pace-setters will average more in their first year of employment than the entire teaching staff will average for the school year.—*Vera Skubic.*

58. PIERSON, WILLIAM R., and RASCH, P. J. "Generality of a Speed Factor in Simple Reaction and Movement Time." *Perceptual and Motor Skills* 11: 123-28; October 1960.

The reaction time and movement time of 32 Ss were measured for arm extension, arm flexion, leg extension, leg flexion, and over-all body speed. For this population, the following conclusions appear justified: (a) reaction time is conditioned by a general factor, (b) movement time is conditioned by a general factor, (c) arm flexion is a faster movement than the others tested, and (d) there is a low, but statistically significant, relationship between RT and MT.—*D. B. Van Dalen.*

59. PILKINGTON, T. E., AND OTHERS. "Diet and Weight-Reduction in the Obese." *Lancet* 7129: 856-58; April 16, 1960.

Kekwick and Pawan stated that during short periods on isocaloric submaintenance diets, weight loss was greater when most of the calories were supplied by fat than when they were supplied by CHO, which they attributed to the greater specific dynamic action of fat. The present study repeated their experiments over a longer period and found no differences in the rates of weight loss on the two diets. The patients on the high fat diet complained of tiredness and nausea, while those of the high CHO diet complained of hunger.—*P. J. Rasch, Journal of the Association for Physical and Mental Rehabilitation.*

60. POWERS, W. T., AND OTHERS. "A General Feedback Theory of Human Behavior." *Perceptual and Motor Skills* 11: 309-23; December 1960.

A two-part theory of human behavior has been presented. Part I deals with a general conceptual model based on a hierarchical arrangement of negative feedback control systems, of the type in which the control loop includes portions of the environment.

Each level of system controls the level below by specifying reference-levels for the controlled systems. Part II outlines applications of the feedback principles to behavior, and introduces six hypothesized levels of perceptual variables associated with human feedback control systems. These levels range from spinal reflexes (First Order Systems) to systems which perceive and maintain orderliness and system concepts (Sixth Order). An organizing system is described.—*D. B. Van Dalen.*

61. Raab, W.; DePaula, E.; Silva, P; Marchet, H.; Kimura, E.; and Starcheska, Y. K. "Cardiac Adrenergic Preponderance Due to Lack of Physical Exercise and Its Pathogenic Implications." *The American Journal of Cardiology* 5: 300-17; March 1960.

The influence of habitual vigorous exercise and of the lack of it, respectively, on the basic cardiac neurovegetative status at rest was studied in 360 healthy American and Austrian men (seventeen to fifty years of age), ranging from competitive athletes, mountaineers, and alpine soldiers to completely sedentary persons. Heart rate and the dynamic cardiac cycle at rest were used as criteria of cholinergic or sympathetic-inhibitory and adrenergic or sympathetic preponderance. A slow heart rate with a long isometric period of the left ventricle at rest was characteristic of the neurovegetative state (cholinergic or sympathetic inhibitory) and the opposite indicative of adrenergic (sympathetic) state.

The authors were able to show that a lack of physical activity leads to an augmentation of the adrenergic state and a decline of cardiac neurovegetative counterregulatory effectiveness. Physical training periods reversed the situation. The adrenergic overactivity is detrimental in that it produces oxygen-wasting, cardiac inefficiency, myocardium-damaging, and possibly atherogenesis. Physical exercise diminishes myocardial, metabolic, and structural vulnerability.—*R. H. Rochelle.*

62. Rasch, Philip J., and Pierson, William R. "Evaluation of a Submaximal Test for Estimating Physical Work Capacity." *Ergonomics* 3: 9-16; January 1960.

The Bruce Physical Fitness Index was examined for reliability and validity, with emphasis on the evaluation of athletes and normal healthy nonathletes. The Index did not correlate well with performance ($r = .47$) for the eleven cross-country runners, and was less sensitive to changes in cardiorespiratory fitness than in oxygen consumption alone. Large individual variations were found on test-retest of 26 normal subjects. Participants in cross-country running and football showed differences which were too great to permit being grouped together as athletes. Possible reasons for the failure of the Index to be more discriminatory were discussed.—*David H. Clarke.*

63. Rasch, P. J.; Pierson, W. R.; and Brubaker, M. L. "The Effect of Amphetamine Sulfate and Meprobamate on Reaction Time and Movement Time." *Internationale Zeitschrift für angewandte Physiologie einschliesslich Arbeitsphysiologie* 18: 280-84; 1960.

Twenty-six adult male subjects were given either a placebo, 20 mg. of amphetamine sulfate, or 800 mg. of meprobamate two hours prior to the administration of tests of reaction time and movement time. The latter tests consisted of releasing a switch and extending the hand through a light beam in response to a visual stimulus. The last five of 20 trials were recorded. Analysis of variance showed that neither reaction time nor movement time was affected by the above drugs which are used widely in connection with the preparation of athletes for competition.—*J. Royce.*

64. Rawley, Donald A.; Glagov, Seymour; and Stoner, Peter. "Measurement of Human Heart Rate During Usual Activity." *Science* 130: 976-77; October 1959.

A small, durable, self-contained, cumulative heart beat counter was assembled from a transistorized amplifier, a counter made from a watch movement, and a battery. The counter is activated by the action current generated by ventricular contraction (the R wave). Heart beats can be counted for intervals of time varying from a few minutes to 24 hours. The authors suggest that this instrument may prove useful in measurement of heart rate during work, physical training, disease, or therapy.—*Clifford E. Keeney.*

65. REDFEARN, J. W. T. "The Eosinopenia of Physical Exercise." *Ergonomics* 3: 17-29; January 1960.

The effect of physical exercise, largely in the form of marching with various loads was examined in 19 young men. All gradations were observed in the eosinopenia effect of physical exercise, varying from no detectable effect compared with control values to the virtual disappearance of the cells from the blood. The depth of the eosinopenia was proportional to the effect of the exercise on the heart rate. For exercises of differing duration, the depth of the eosinopenia was found to be proportional to the duration of the exercise when the heart rate was kept constant. The virtual disappearance of eosinophils from the blood corresponds roughly with the inability of the individual to continue the exercise of his own free will.—*David H. Clarke.*

66. ROHMERT, W. "Zur Theorie der Erholungspausen bei dynamischer Arbeit" (On the Theory of Rest Periods in Dynamic Work). *International Zeitschrift für angewandte Physiologie einschliesslich Arbeitsphysiologie* 18: 191-212; 1960.

Seven male subjects exercised on a bicycle ergometer for one hour at a 60 rpm pace. The duration of the intermittent work and rest periods as well as the workloads were varied during the one-hour period. Data were collected on the recovery pulse rate, the increase in mean minute pulse rate during the work, and the last-minute working pulse rates. The fatigue, as expressed by combination of the above variables, increases exponentially with the work period duration as well as with the workload. The mathematical equation expressing the relationship of these variables is presented.—*J. Royce.*

67. SAUNDERS, JOSEPH F. "Cholesterol: the Perplexing Metabolite." *Naval Research Reviews* 11-15; April 1960.

Cholesterol is a topic of scientific curiosity, dietary faddism, and medical controversy. The implications which have associated high levels of cholesterol, heart attacks, atherosclerosis, and other disorders of the blood vessels are based on data which are premature, incomplete, and contradictory. Chemically, cholesterol is a crystalline or solid alcohol known as sterols. Among the tasks it performs are (a) it serves as a structural component of certain tissues; (b) it is a precursor to vitamin D_3; (c) it is a precursor to the body steroids and steroid hormones; and (d) it is a precursor to the sex hormones. The body synthesizes about 1.5 g. per day, a quantity exceeding that normally consumed in a day. It is possible in atherosclerosis that the body produces more than is needed or that it cannot handle normal amounts properly. Cholesterol may be manufactured by the nerve from choline and is associated in some way with the transfer of the nerve impulse. High blood cholesterol levels aid in identifying disturbances in the fat metabolism of the body and should be considered in health surveillance programs.—*P. J. Rasch, Journal of the Association for Physical and Mental Rehabilitation.*

68. SHAFTEL, NORMAN; SELMAN, DAVID; KUHN, PAUL H.; and HALPERN, ALFRED. "Electrocardiographic Changes Produced by the Valsalva Maneuver in Healthy Adults." *Journal of Cardiology* 5: 473-76; April 1960.

Electrocardiographic studies were carried out in 209 persons free from detectable heart disease during the performance of a standard Valsalva Maneuver. Significantly lowered T waves and depressed S-T segments were observed in one-fourth of the cases. Other changes included extra-systoles, partial heart blocks, slurring of QRS complex and T-P fusion.

The authors attempt to explain changes in four categories, namely, (1) alterations in position of heart, (2) muscular effect of the Valsalva Maneuver, (3) period of apnea, and (4) hemodynamics of Valsalva Maneuver. The fourth appears to be the more realistic answer since blood is pooled in the extremities and cardiac filling is reduced. As a result, the authors are of the opinion that it is reasonable to assume a corresponding minimal coronary artery perfusion, resulting in a decrease of myocardial nutrition.—*R. H. Rochelle.*

Announcement to Members

At its annual convention in April 1960, the American Association for Health, Physical Education, and Recreation took decisive action to assist in raising standards of professional preparation, linking this action with a new AAHPER membership requirement.

- The Association designated the National Council for the Accreditation of Teacher Education as the official accrediting agency for teacher education in health, physical education, and recreation. Appropriate organizations and agencies are being urged to support NCATE accreditation in every possible way.

- The Association also stipulated that after June 1, 1964, *all new* professional, fellow, life, and life fellow members must have at least one graduate or undergraduate degree, with a major or minor in health, physical education, or recreation, from an NCATE-accredited institution. After this date, any person who permits his membership to lapse more than one year must fulfill the requirement made of *new* members. Persons applying for membership after June 1, 1964, who do not meet the above requirement may be designated as associate members. (An article in the May-June 1961 JOURNAL describes the functions and procedures of the NCATE and lists the NCATE accredited institutions offering degrees in health education, physical education, and recreation.)

Research Requirements—1961

Research Methods in Health, Physical Education, Recreation

This indispensable book should be part of every researcher's library. *Research Methods* describes methods and techniques of conducting research in the fields of health, physical education, and recreation that are necessary for teacher and student alike. Second edition.

1959. 536 p. $6.00

Contributions of Physical Activity to Human Well-Being

This outstanding supplement to the May 1960 RESEARCH QUARTERLY defines the contributions of physical activity to physical health, social development, psychological development, skill learning, growth, and rehabilitation. All the significant research in these areas has been collected in celebration of AAHPER's 75th Anniversary. Contributors include Fred V. Hein, Allan J. Ryan, Charles C. Cowell, M. Gladys Scott, Dorothy R. Mohr, Anna S. Espenschade, Arthur S. Abramson, and Edward F. Delagi.

1960. 394 p. $1.25.

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